ENVIRONMENTAL PERFORMANCE OF COCOA PRODUCTION FROM MONOCULTURE SYSTEM AND AGROFORESTRY SYSTEM IN INDONESIA

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**A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
IN ENVIRONMENTAL TECHNOLOGY AND MANAGEMENT**

**THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI**

2ND SEMESTER 2013

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Topic: Environmental Performance of Cocoa Production from Monoculture System and Agroforestry System in Indonesia

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ABSTRACT

Indonesia still tries to expand its cocoa production to meet increased international demand. However, this effort faces economies of scale and ecological challenges. This research aimed at evaluating environmental performance of cocoa production from cocoa monoculture and cocoa-agroforestry by life cycle assessment based on ISO 14040 and 14044, with adaptation for local impact indicators. This study defined cocoa-agroforestry as raw and sequential of cocoa-coconut and cocoa-rubber agroforestry, combined with shading trees *Leucaena sp* and *Gliricidia sepium.* The analysis considered cocoa production at farm level, from cradle to on-farm gate boundary for 1 metric tonne of cocoa pod. The results showed that cocoa-coconut agroforestry had the least contribution to global impact categories of global warming, acidification and eutrophication, accounted for 3.67E+01kg CO_2-eq, 4.31-02 kg SO_2-eq, and 2.25E-05kg PO_4-eq respectively. Cocoa-coconut agroforestry also had the highest organic carbon and soil organic matter, of which these conditions supported the growth and activity of beneficial soil microbeds (*Pseudomonas sp* and *Trichoderma sp*). In addition, total land equivalent ratio of cocoa-coconut agroforestry had the highest value at 1.36, indicating a highest yield advantage was gained. Therefore, cocoa agroforestry could be a wise option to promote environmental sustainability of cocoa farming practices.

Keywords: Environmental Performance, Life Cycle Assessment, Cocoa Agroforestry, Indonesia

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CHAPTER 1
INTRODUCTION

1.1. Rationale

Cocoa (*Theobroma cacao*) is one of the world's most valuable crops. Cocoa is cultivated by 5-6 million cocoa farmers worldwide and serves as an important crop: a cash crop for growing countries and a key import for processing and consuming countries. Total cocoa production worldwide has increased in absolute terms from 3.66 million metric tonnes in 2007-2008 to 3.98 million metric tonnes in 2011-2012, out of which more than 90% of world cocoa production are provided by small cocoa farms. Around 40-50 million people depend on cocoa for their livelihood (Cocoa Market Update, 2012).

Around 3.5 million tonnes of cocoa are produced each year, but rising incomes in emerging markets such as India and China, combined with anticipated economic recovery in the rich North, have led to industry forecasts of a 30% growth in demand to more than 4.5 million tonnes by 2020. This should be good news for farmers and businesses alike. But complacency and disregard for the livelihoods of more than five million small-scale family farmers who grow 90% of the world's cocoa mean that the industry may simply be unable to provide sufficient supply to meet the demand (The Guardian, 2013).

As there are no alternative crops or synthetic products to make chocolate available in the market, cocoa production is expected to increase to meet the steady international market demand. A steady demand from worldwide consumers draws numerous global efforts and funds committed to support and improve cocoa farm sustainability (Cocoa Market Update, 2012).

In spite of increased market demand, cocoa production still remains sensitive to environmental issues. Consumers in developed countries demand safe food of high quality that has been produced with minimal adverse impacts on the environment (Boer, 2002). The environmentally conscious consumer of the future will consider ecological and ethical criteria in selecting food products (Andersson et al., 1994). The ecological impact of cocoa cultivation system is being discussed with focus on practices that conserve biological hotspots, protect the environment, promote global carbon sequestration, cause no health problems and enhance the quality of life for farmers and society as a whole.

Indonesia, located on 6°N-10°S latitude and 95-141° E longitude, is a well-suited place to cultivate cocoa. According to FAO Statistics (2013), Indonesia is the second largest producer of cocoa in the world with annual average 779,899 metric tons of cocoa beans production since 2006 – 2011. It was also reported that during 2006 – 2011 the average export of cocoa reached $873.98 million, placing cocoa as the third largest of Indonesia's agricultural export commodity after palm oil and rubber (Ministry of Trade, 2012). Over 85% of cocoa beans are cultivated on the island of Sulawesi, the remaining 15% on other islands such as Kalimantan and Sumatra (Ministry of Industry, 2007).

Indonesia's cocoa production also faces challenges. The cocoa yields in some regions are declining. In Sulawesi smallholder plantations for instance, it has declined from 1500-2000 to 900-1200 kg/ha in the alluvial plains and from 1000-1300 to less than 600 kg/ha in the hills. Due to current low productivity, cocoa cultivation is expanded into new areas including forest lands or intensified by fertilizer application to push yield putting undue pressure on the environment. Opening vast areas of rainforest to cocoa production became viable in some regions, providing better fertile land spaces to increase the cocoa production. Encroachment in the Lore Lindu National Park has become one of the cases that threaten the integrity of rainforest adjacent to the cocoa-growing regions. A study of land use in this area found that forestland conversion to agricultural use by rural communities has caused land use to change substantially, leading to forest degradation (Reetz and Brummer, 2011).

To boost cocoa production, the Indonesian government launched the Gerakan Revitalisasi Kakao Nasional (National Movements on Revitalized Cocoa) in 2008. The program includes the rehabilitation and the intensification of 1.6 million ha of cocoa fields, and expects to produce 2 million tons of cocoa annually to be the world's top cocoa producer by 2020 (Indonesia Investment, 2013). The program also follows the principle of sustainability and recommends the application of polyculture as combined plantation of cocoa and other valued species to obtain better economic, social and environmental advantages (Neilson, J. 2008). Given the fact that cocoa trees naturally need shade and are not very suitable for large-scale monoculture plantations, intercropping with other cash or food crops is becoming a common practice.

1.2. Literature Review

1.2.1. Environmental Issues on Cocoa Cultivation

The International Cocoa Agreement, 2001 in Article 39 makes specific reference to the issue of sustainability and encourages its country members to give due consideration to the development of a sustainable cocoa economy, which was adopted by the United Nations Conference on Environment and Development on 14 June 1992. In the light of this mandate, it is incumbent upon all interested parties including the governments of cocoa producing and consuming countries, the international donor community, the cocoa trade, the chocolate industry and organized civil society to work together to find ways to include all three pillars of sustainable development in the decision-making process on issues related to cocoa production and consumption (United Nations, 2000).

Environmental sustainability aspects in cocoa cultivation may encompass the conservation of soil, forest and water resources, as well as biodiversity protection. Cocoa growing areas can maintain a quite high level of biodiversity, and as a minimum standard, must not cause damage to the environment. The biodiversity and soil nutrients in cocoa growing areas should be preserved and conservation efforts must be made to ensure that the right balance between environment and cocoa cultivation is maintained (ICCO, 2007). In this regard, a few important elements require particular attention, including the role of shade trees, soil conservation and management, prevention of forest clearing, integrated pest management and diversification of farm incomes. These will retain the ability of agroecosystem remaining productive in the long term as well as being competitive in the global market.

Cocoa cultivation systems must be managed in a way that can reduce risks and include sustainably aspects. Resource utilization and evaluation of environmental impact pertaining to cocoa cultivation must be taken into account in the early stages of the cocoa life cycle. However, the field findings suggest that current intensified agriculture practices contribute negative impacts to the environment. Agricultural production is usually a hotspot in the life cycle of food products (Poritosh et al., 2009), with the farm stage being a major contributor to the following impact categories: global warming, eutrophication and toxicity impacts (Solomone 2003; Pleanjai and Gheewala 2009; Humbert et al., 2009; Cappellati et al., 2010). The hotspots of emissions contributing to the three mentioned impact categories are the production and use of fertilizers, notably for global warming and eutrophication, and pesticide and how fertilizers are used, for their toxicity impacts (Ntiamoah and Afrane, 2008).

Efforts to reverse the trend of intensified cocoa plantations are focusing on the reintroduction of shade trees. Shade trees are valuable in enhancing biophysical conditions on cocoa fields and contribute to biodiversity and product diversification for smallholder producers (Obiri et al., 2007). Shaded cocoa has been described as one of the best examples of permanent agriculture that in some way preserves a forest environment and its biodiversity (Ruf and Schroth, 2004), supporting higher levels of biodiversity do than most other tropical crops (Rice and Greenber, 2000).

1.2.2. Benefits of Cocoa Agroforestry System

A growing interest worldwide in agroforestry has emerged over the last few years. This cropping system offers numerous advantages with respect to food security and income source diversity for smallholders, biodiversity conservation, soil preservation, and pest and disease control (Avelino et al., 2011; Ruf and Schroth, 2004). Multispecies systems, such as agroforestry systems, tend to be presented as more sustainable than mono-specific cropping systems for a range of reasons including, (1) biodiversity preservation and consequent greater resilience, (2) reduced use of fertilizers due to increased nutrient recycling and nutrient-use efficiency, (3) soil conservation and water quality thanks to increased soil cover and reduced runoff and (4) income stability due to diverse income sources and lower dependence on external inputs and product prices. (Malézieux et al., 2009).

Other benefits of shade trees provided by cocoa agroforestry as compared to un-shaded cocoa plantation include a buffer of the microclimate as well as reduction of attack by weeds and the parasitic plants on cocoa. Shade trees buffer high and low temperature extremes by as much as 5ºC and are capable of producing up to 14 Mg ha^{-1} $year^{-1}$ of litter fall and pruning residues containing 340 kg N ha^{-1} $year^{-1}$. Furthermore, maintaining 10 large or 15 medium trees per hectare helps to reduce damage to cocoa caused by insect pests (Ruf and Schroth, 2004). In the Ashanti region of Ghana, shade trees act as alternative hosts to parasitic plants such as mistletoe, which otherwise use the cocoa as a host plant, depriving it of nutrients and thereby reducing yield (Obiri et al., 2007). In West Africa, the un-shaded cocoa plantations have proved to be more productive especially when full sunlight is combined with fertilization (Wessel, 1985). However, such practices present certain risks since unshaded cocoa plantations are vulnerable to insect pests and consequently require intensive phytosanitary protection.

Mirids (*Sahlbergella singularis* and *Distantiella theobroma*) cause varying degrees of cocoa tree damage, leading to premature ageing of plantations and sometimes tree death when chemical protection is inadequate. When compared to full sun plantations, traditional systems have proven to be significantly less damaged by mirids (Entwistle, 1972). Mirid populations of traditional cocoa systems in Cameroon are often restricted to cocoa trees exposed to the sun in the canopy breaks (Babin et al., 2010). This raises the idea of using plant diversification in cocoa agroforestry systems as a pest management strategy which should lead to a decrease in chemical input needs.

Cocoa-coconut intercropping with traditional cultivation under *Gliricidia sepium* shade has been commonly practiced. In Indonesia and Malaysia, cocoa is sometimes planted under coconut trees (Daswir and Dja'far, 1988). Mixed cropping systems of coconuts with cocoa, rubber (*Hevea brasilensis*), mango (*Mangifera indica*), cashew (*Anacardium occidentale*), breadfruit (*Artocarpus communis*) and citrus are also common. Research by Pramono and Wignjosoemarto in Karmawati et al., (2010) on cocoa and coconut multi-cropping system in East Java, Indonesia, showed that the production of cocoa under the shade of coconut trees is normal and stable, having almost similar productivity as the monoculture system. Such conditions could be achieved through coconut tree space 12.0 m × 8.0 m or the density of coconut tree at 104 trees/ha and cocoa tree space 3.0 m × 2.0 m or 1.152 trees/ha.

1.2.3. Environmental Impacts Evaluation of Agriculture at Farm Level

It is well known that agricultural practices have impacts on nature. Given the increased public attention to the areas of protection, the need to assess the environmental impacts of agriculture has also been spreading out to a large number of agricultural commodities. However, the efficient methods to comprehend and assess agricultural impacts on the environment by combining suitable indicators are very much needed. One of the methods considered is life cycle assessment (LCA).

LCA is a method that can be used to assess the environmental impact of agriculture, but impact categories and the functional unit of classical LCA's must be adapted to the specific agricultural production processes (Haas et al., 2000; Van der Werf and Petit, 2002; Brentrup et al., 2004). Van der Werf et al. (2010) reported that the French Government has recently launched a national program to label food products with indicators of their environmental impacts. For this, LCA is the chosen methodology as it notably makes it possible to compare impacts of the same product produced in different regions.

The application of LCA to agriculture has specific characteristics (Table 1.1). Depending on the environmental impact and aim of the investigation, different functional units can be chosen such as a farm, an area, a livestock and a product (Haas et al., 2000). ross profit is also used as a functional unit for expressing the financial function (Mouron et al., 2005). Indicators allowing the expression of impacts both per unit surface and per unit product are preferable, since these allow the evaluation of agricultural systems both as modes of land use and as productive systems (Van der Werf and Petit, 2002). Therefore, the uses of multiple functional units are applicable.

An important fact of LCA applied to agriculture is that the boundary of the agricultural system reflects the cradle-to-gate type of LCA (Table 1.1). It may be correct to perform cradle-to-gate type LCA under some assumptions. The geographical coverage of LCA in agriculture is the area of the farms. Input industry is only considered for energy and mineral fertilizer production, whereas the output industry is not a part of the assessment. A purely agricultural LCA is carried out rather than an LCA of food products by assembling agricultural and food processing process (Cowell and Clift, 1997).

Table 1.1. Selected applications of LCA to agriculture at farm level

Author (s)	**Issues**	**Alternatives**	**Functional units**	**Cradle to gate**	**LCIA**
Hanegraaf et al. (1998)	Energy crop production in the Netherlands	Route and crop (GAP)	1 GJ and 1 ha	Cradle-to-gate	Midpoint
Haas et al. (2001)	Grassland farming in Germany	Intensive, extensive, and organic farming	1 ha and 1 t milk	Gate-to-gate	Midpoint
Brentrup et al. (2001)	Sugar beet production in Germany	Sugar beet production with calcium ammonium nitrate (solid fertilizer), urea (solid fertilizer), and urea ammonium nitrate solution (liquid fertilizer)	1 t of extractable sugar	Cradle to gate	Midpoint
Brentrup et al. (2004)	Winter wheat production in the UK	Nitrogen fertilizer rate	1 t of grain	Cradle to gate	Midpoint
Anton et al. (2005)	Greenhouse tomato production	Soil cultivated, open, and closed hydroponic system	1 kg of tomatoes	Cradle to gate	Midpoint

	in Spain	(+3 waste management scenarios)			
Charles et al. (2006)	Wheat crop production in Switzerland	Fertilization intensity level (4 treatments of N, P, and K fertilization)	1 ha and 1 ton of grain produced	Cradle to gate	Midpoint
Wood et al. (2006)	The wider, global impacts of farming in Australia	Conventional and organic farming	Impact per $ or million-$ of output	Cradle to gate	Midpoint

Given the specific agricultural background, impact categories considered as central environmental impacts of agriculture differ from the classical LCA's product, process and production system of enterprises. The impact categories and environmental indicators commonly used in agricultural LCAs are presented in Table 1.2.

Table 1.2. Impact categories and indicators in agriculture LCA's

Impact category	**Environmental Indicator**
Global Impact a. Resource consumption - Energy - Minerals	 Use of primary energy Use of P- and K- fertilizer
b. Global warming potential	CO_2, CH_4, N_2O-emissions
Regional to International Impact a. Soil function/strain - Grassland - Of other ecosystems (N-eutrophication, acidification)	 Accumulation of heavy metals NH_3, NO_x, SO_2-emissions
b. Water quality - Ground water (Nitrate leaching) - Surface water (P-eutrophication)	 N-fertilising, N-farmgate-balance, potential of nitrate leaching P-fertilising, P-balance, % of drained area
c. Human and ecotoxicity	Application of herbicides and antibiotics, potential of nitrate leaching, NH_3-emission
Local to Regional Impact Biodiversity	 Grassland (number of species, date of first cut), hedge and field margins (density, diversity, state, care)
Landscape image (aesthetics)	Grassland, hedges and field margins (see above), grazing animals (period, breed, alpine cattle keeping), layout of farmstead (regional type, building, garden)
Animal husbandry (appropriate animal welfare)	Housing system and conditions, herd management (e.g. lightness, spacing, grazing seasons, care)

Source: Hass et al. (2000).

Multifunctionality and allocation in LCA occurs when the output produced comprises more than a single product, and raw material inputs often include intermediates or discarded products (Guinée J. B., 2002). Therefore, LCA applied to agroforestry systems raise the question of impact allocations between associated crops.

Several issues need to be taken into account in the application of LCA in agroforestry. One of them is that agroforestry systems are highly diversified so that different approaches and methods may be needed. In this regard, three interconnected dimensions need to be considered. The first dimension is the spatial arrangement of the crops, both in vertical and horizontal directions. The second dimension is the timing of crop developments, which is correlated to the spatial dimension. The last one is the functional dimension of the diverse crops, i.e. cultivated for their products or as providers of specific functions, such as shade or N fixation. In traditional LCA, time and space are hardly accounted for, whereas the system function is the basis for the calculation (Bessou et al., 2012).

The LCA of agroforestry systems should therefore seek a comprehensive description within the system (Bessou et al., 2012). Further, identifying and quantifying all services of an agroforestry system, which is a complex matter especially due to collective dynamics that may lead to emergent properties that cannot be deduced from species properties alone also become issues (Malézieux et al., 2009).

Given the above premises, there is a need for a scientific study that can perform a comprehensive evaluation on cocoa production based on a cocoa monoculture and a cocoa-agroforestry system. Such a study would provide comparable figures of environmental impacts from the systems and promotes sustainable agricultural practices in cocoa cultivation. For such purposes, life cycle assessment can be employed as an analytical environmental tool in assessing and comparing the environmental impacts due to energy and materials used and pollutants released, as well as figuring environmental performance and benefits gained at the cultivation stage from the systems.

1.3. Objectives

The objectives of this study are as follows:

1. To evaluate the environmental impacts of cocoa pod production on the farm level

based on a cocoa monoculture and a cocoa agroforestry systems by using the method of life cycle assessment.

2. To compare the environmental performance of cocoa production between cocoa monoculture and cocoa agroforestry systems based on a life cycle perspective.
3. To measure the economic productivity of cocoa cultivation in the systems under study.
4. To provide suggestions for decision-making associated with the development of the cocoa production system in Indonesia.

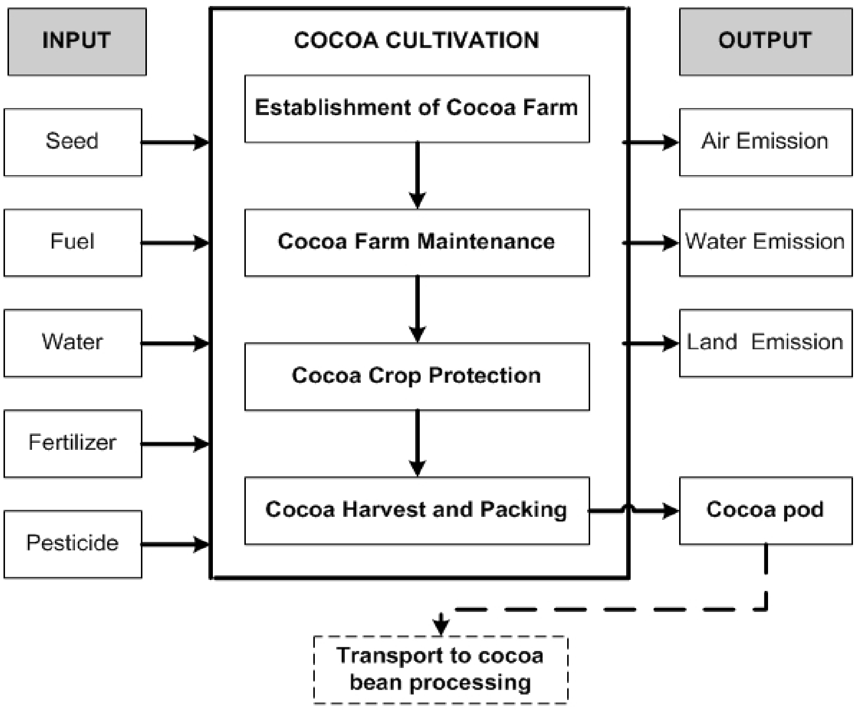
1.4. Scope of Research Work

The application of cradle-to-gate type of LCA based on ISO 14040 and ISO 14044 was chosen as the assessment tool in this study. In order to evaluate the environmental impacts of cocoa pod production at farm level, with cultivation systems of cocoa monoculture and cocoa-agroforestry. Due to the system complexity and data availability on agroforestry, the study selected a simply structured system, "sequential or row agroforestry" referring to cocoa-intercropping system (Table 1 in Malézieux et al., 2009) where the performances and impacts could be quantified for each crop individually, based on corresponding crop performances and impacts assessed in single-crop systems (Bessou et al., 2012).

The life cycle assessment of cocoa pod production focused on farm level activities, which consist of (1) the nursery stage, (2) the unproductive stage (immature phase and any decline in production at the end of cycle), and (3) the productive stage. The life cycle of monoculture cocoa cultivation started from the establishment of farm, farm maintenance, crop protection, harvesting and packing, while the life cycle of cocoa agroforestry started from the establishment of cocoa agroforestry farm, cocoa agroforestry farm maintenance, cocoa agroforestry protection, cocoa and agroforestry co-products harvesting and packing.

Provided that LCA in cocoa agroforestry systems create problems related to multi-functionality and allocation, the ISO allocation procedure was carried out in this study to settle such problems, in the form of system expansion or avoided burdens, as well as partitioning. This study considered the first principle of avoided allocation. Since the plots of cocoa agroforestry in this study were managed by big estate company, not farmers' or households' cocoa farm, data inventory of materials, energy and resource input to and output from each tree species exist in cocoa-agroforestry system were well recorded and accessible. Whenever un-avoided, allocation was applied at specific data inventory, for instance data from the activity of irrigation. The environmental burdens due to energy consumption to irrigate (spray water) into cocoa-agroforestry farm were separated between co-products yield from each tree species, based on the mass or economic values of co-product. This study used economic values of co-product as the basis for allocation

The boundaries of the systems for LCA with a cradle-to-farm-gate boundary of both models are illustrated in Figures 1.1 and 1.2. The study employed functional unit (FU) of 1 tonne of cocoa pod. All the inputs and outputs in the life cycle inventory were expressed with reference to the functional unit. The use of the first functional unit conformed that the LCA-based method regards the farm as a production system.

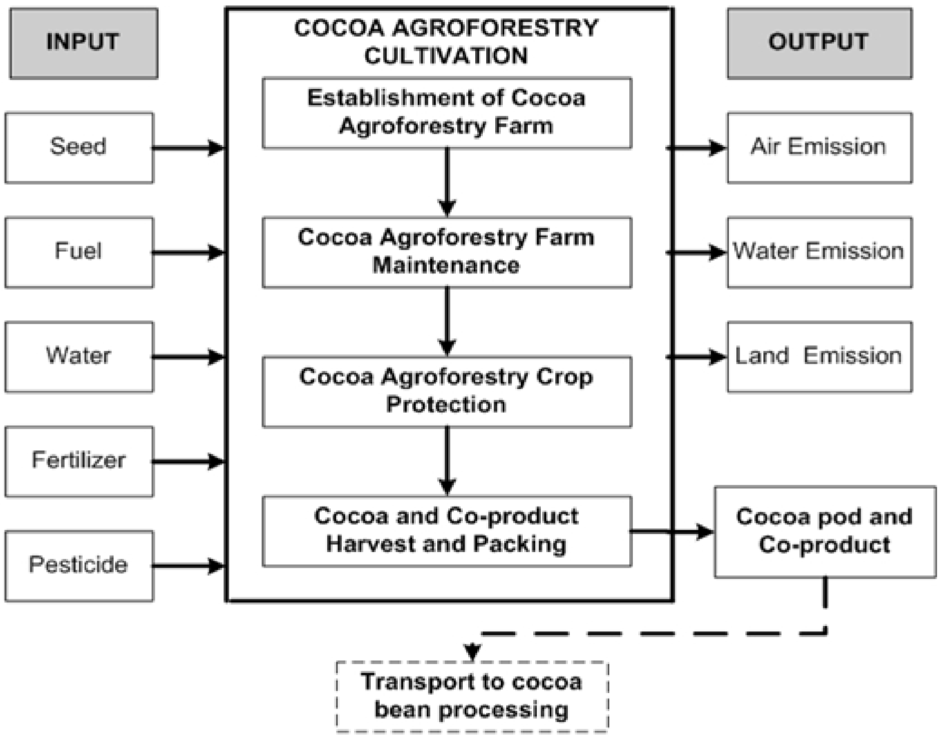


Note: The processes captured in the dot box was excluded from the study

Figure 1.1. The boundary of a cocoa monoculture system

The results of this study can be used for cocoa-related stakeholders – particularly respective governments, cocoa scientists, cocoa research institutes, Indonesian Cocoa Board, APKIC (Indonesia's Association of Cocoa and Chocolate Industries and Factories), cocoa cooperatives and farmers – those who are in decision-making for the improvement of the cocoa industry and the environment.

The first examination of environmental impacts focused on global and regional impacts: global warming, acidifying and eutrophication emissions associated with resource and energy usage in the systems studied as these impacts were mainly contributed at the cultivation stage (Nguyen and Gheewala, 2008; Ntiamoah and Afrane 2008; Humbert et al., 2009). The second examination focused on localized ecological impacts by which the impacts of soil quality were accounted. This could be described using estimation score (Hass et al., 2000). In terms of ecological impacts, the commonly studied impacts include land use effects on species diversity, soil erosion, soil organic matter changes (Koellner and Scholz, 2008). The LCA is a less developed and standardized tool for assessing local ecological impacts, so these kinds of impacts could be described quantitatively on a functional unit basis or qualitatively (Pelletier et al., 2007). Further, economic productivity due to the cocoa cultivation system applied was measured. Simple method was used to assess the benefits of multispecies systems by estimating their productivity using the Land Equivalent Ratio (LER) (Mead and Willey, 1980).



Note: The processes captured in the dot box was excluded from the study

Figure 1.2. The boundary of the cocoa agroforestry system

However, environmental emissions caused by infrastructure development, such as manufacturing machines, buildings, vehicles, and labour activities associated with the stages of cocoa pod production on farm were not assessed in this study. The justification associated with this study is elaborated in Chapter 3.

CHAPTER 2
THEORIES

2.1. Cocoa (*Theobroma cacao*)

2.1.1. Cultivar

The cocoa tree belongs to the genus *Theobroma*. Within this genus different species and subspecies can be identified. These subspecies can be classified within four cultivars: Criollo, Forastero, Trinitario and Nacional. However, in the literature cocoa beans might be named differently, depending on origin, commercial names, habitats and so on. Trinitario is a cultivar which is commonly grown in Indonesia. The Trinitario planting was started in Trinidad, spread to Venezuela and then to Ecuador, Cameroon, Samoa, Sri Lanka, Java (Indonesia) and Papua New Guinea (ICCO, 2013).

2.1.2. Practices of Cocoa Cultivation

In the broadest sense, applying the sustainable practice of cocoa production will be more demanding in recent days. In 2008, ICCO (International Cocoa Organization) published the manual of best known practices in cocoa production, aimed at achieving the adoption of improved cultivation practices for the cocoa farmer. Other reasons to apply best known practice in cocoa production are that, the first: only in this way can the highest physical quality standards be reached, given the planting material used and the second: in this way, food safety legislative standards can be met, thus avoiding any problems in the utilization and trade of the beans (ICCO, 2013).

The manual also includes information from Good Agricultural Practices (GAP) and provides the standards that can be reached to achieve sustainable cocoa production, covering the aspects of economic, social and environmental sustainability. In general, the manual has outlined best known practices in cocoa production as follows: (1) Establishment of the cocoa farm; (2) Cocoa farm maintenance and crop husbandry; (3) Cocoa crop protection; (4) Cocoa harvest, post harvest, on-farm processing and storage, including quality control, Transportation and Shipping Practices, Cocoa food safety; (5) Human welfare, health and safety of cocoa producers, and (6) Farm record keeping (ICCO, 2013).

a. Climate Conditions

The natural habitat of the cocoa tree is in the lower storey of the evergreen rainforest, and climatic factors, particularly temperature and rainfall, are important in encouraging optimum growth. Cocoa plants respond well to relatively high temperatures, with a maximum annual average of 30 - 32ºC and a minimum average of 18 - 21ºC.

Variations in the yield of cocoa trees from year to year are affected more by rainfall than by any other climatic factor. Trees are very sensitive to a soil water deficiency. Rainfall should be plentiful and well distributed through the year. An annual rainfall level of between 1,500 mm and 2,000 mm is generally preferred. Dry spells, where rainfall is less than 50 mm per month, should not exceed three months. A hot and humid atmosphere is essential for the optimum development of cocoa trees. In cocoa producing countries, relative humidity is generally high: often as much as 100% during the night, falling to 70-80% during the day.

The cocoa tree will make optimum use of any light available, and traditionally, has been grown under the shade. Its natural environment is the Amazonian forest which provides natural shade trees. Shading is indispensable in a cocoa tree's early years.

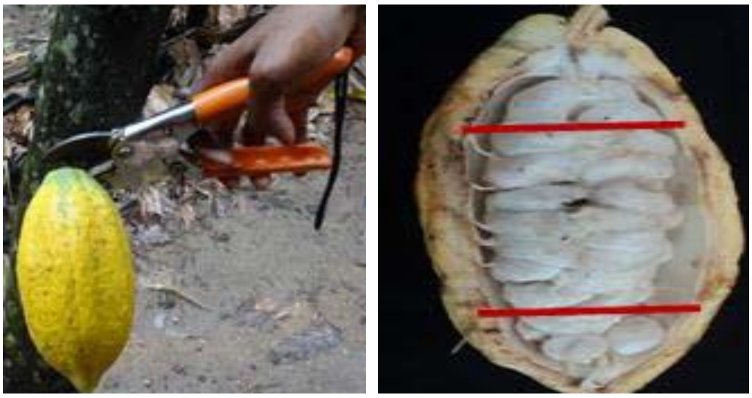
b. Soil Conditions

Cocoa is grown in a wide variety of soil types. Cocoa needs soil containing coarse particles with a reasonable quantity of nutrients to a depth of 1.5 m to allow the development of a good root system. Below that level it is desirable not to have impermeable material, so that excess water can drain away. Cocoa will withstand water logging for short periods, but excess water should not be longer. The cocoa tree is sensitive to a lack of water, so the soil must have both water retention properties and good drainage.

The chemical properties of the topsoil are most important, as the plant has a large number of roots for absorbing nutrients. Cocoa can grow in soils with a pH in the range of 5.0-7.5. Therefore cope it can with both acid and alkaline soil, but excessive acidity (pH 4.0 and below) or alkalinity (pH 8.0 and above) must be avoided. Cocoa is tolerant of acid soils, provided the nutrient content is high enough. The soil should also have a high content of organic matter: 3.5% in the top 15cm of soil. Soils for cocoa must have certain anionic and cationic balances. Exchangeable bases in the soil should amount to at least 35% of the total cation exchange capacity (CEC), otherwise nutritional problems are likely. The optimum total nitrogen / total phosphorus ratio should be around 1.5.

c. Seedling and Propagation

Cocoa is raised generatively by using seed and vegetatively by clonal materials from seeds that are extracted from pods. Cocoa pods take 150-170 days from pollination to attain the harvest stage. The stage of maturity is visible from the change of pod colour from green to yellow or from red to orange (Figure 2.1.). The best seeds for sowing are those from all parts of the pod.



. (a) (b)

Figure 2.1. Cocoa seed propagation. (a) Ripe cocoa; (b) Seeds for sowing

Seeds will germinate and produce good plants when taken from pods that are not more than 15 days under-ripe. The best potting media for growth and development of cocoa seeding comprises of top soil, sand, FYM (Farm Yard Manure) at 2:1:1. Tree cuttings are taken with between two and five leaves and one or two buds. The leaves are cut in half and the cutting placed in a pot under polyethylene until roots begin to grow. A bud is cut from a tree and placed under a flap of bark on another tree. The budding patch is then bound with raffia and waxed tape of clear plastic to prevent moisture loss. When the bud is growing, the old tree above it is cut off. A strip of bark is removed from a branch and the area covered in sawdust and a polyethylene sheet. The area will produce roots and the branch can then be chopped off and planted. However, the grafting is much more applicable than budding.

If seedlings are used as plantings, vigorous and healthy seedlings should be selected. In Indonesia the hybride seeds must be obtained from specific seed garden which had been recommended by Ministry of Agriculture. The planting material should be of 4-6 month old seedling or grafted or budded plant. The seedling/grafted/budded plant (Figure 2.2) should be planted in the centre of the pit, not too deep. While planting grafts, polythene strip tied over graft joint should be removed and the joint should be above the soil.

(a). (b) (c)

Figure 2.2. Seed planting technique. (a) Seedlings; (b) Budded plants; (c) Grafted plants.

d. Planting Method

Cocoa is a fast-growing tropical forest plant cultivated in association with other trees and tall plants to provide shade. During its seedling period it requires about 50% shade and later the shade requirement is about 20-30%. The cocoa tree can be as tall as 8-12 m with tap-roots about 2 m deep. The main harvest usually begins at the end of the wet season and may extend for 3 months.

Cocoa can be grown in multi-strata and diversified agroforestry systems where the canopies of cocoa tree are joined up and form a thick layer of foliage shaded by the canopy of neighbor trees (Wessel, 1985). As a tree crop, cocoa is highly suitable with different production systems, such as agroforestry, intercropping farming, etc. The existence of trees with crops defines an agroforestry system (Malézieux et al., 2009), while the practice of growing two or more crops in proximity in the same field to promote interaction between them defines intercropping (Figure 2.3).

The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. This allows for diversified production to include timber and firewood, fruits, construction materials, honey, resin, medicine, etc. Careful planning is required, taking into account the soil, climate, crops, and varieties. It is particularly important not to have crops competing with each other for physical space, nutrients, water, or sunlight. Examples of intercropping strategies are planting a deep-rooted crop with a shallow-rooted crop, or planting a tall crop with a shorter crop that requires partial shade.

Intercropping of compatible plants also encourages biodiversity by providing a habitat for a variety of insects and soil organisms that would not be present in a single-crop environment. This in turn can help limit outbreaks of crop pests by increasing predator biodiversity. Additionally, reducing the homogeneity of the crop increases the barriers against biological dispersal of pest organisms through the crop.

The degree of spatial and temporal overlap in the two crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop. Numerous types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been identified. These are some of the more significant types:

- Mixed intercropping is the most basic form in which the component crops are totally mixed in the available space.
- Row cropping involves the component crops arranged in alternate rows. Variations include alley cropping (crops are grown in between rows of trees) and strip cropping (multiple rows, or a strip, of one crop are alternated with multiple rows of another crop).
- Intercropping also uses the practice of sowing a fast growing crop with a slow growing crop. The fast growing crop is harvested before the slow growing crop starts to mature. This obviously involves some temporal separation of the two crops.
- Temporal separation is found in relay cropping, where the second crop is sown during the growth often near the onset of reproductive development or fruiting, of the first crop, so that the first crop is harvested to make room for the full development of the second.

(a) (b)

Figure 2.3. Cocoa planting (a) Cocoa-monoculture; (b) Cocoa- agroforestry

Source: Malézieux et al., (2009).

e. Irrigation in cocoa

Cocoa is usually grown in areas where water availability is adequate. Cocoa plants are sensitive to drought; therefore, irrigation becomes essential. The crop requires irrigation at weekly intervals. When it is grown as mixed crop, the crop is to be irrigated once in a week during November-December, once in 6 days during January-March and once in 4-5 days during April-May with 175 liters of water.

Table 2.1. Indicative water requirement responding to cocoa plant age

Age of the plant	Water requirement (liter/plant/day)
1st year	3-5
2nd year	10
3rd year and later	20-25

f. Soil nutrient management

Soil nutrient management is critical to maintain general health for trees, particularly where cocoa trees are grown on poor soils with low nutrient levels. The fertility of soils under cocoa plantations with complete canopy formation can be maintained or sustained for a fairly long time due to the ability of cocoa and other shading trees litters to recycle nutrients back into the soil. However, continuous harvesting will eventually result in the loss of soil nutrients.

Table 2.2. Indicative dosage of fertilizer responding to cocoa plant age

Fertilizer (g/plant)	1st year	2nd year	3rd year and later
Urea	72	144	220
Rock phosphate	65	130	200
Muriate of Potash	77	154	230

g. Fertilizer schedule for cocoa

An annual application of fertilizer should be applied in two equal splits, which is commonly applied at the beginning and at the end of rainy season. The first dose application will be in April- May and the second dose in September- October. Fertilizer may be applied uniformly around the base of the tree up to a radius of 30 cm during the first year, forked and incorporated into the soil. For grown up plants, the best method is to rake and mix the fertilizers with soil in shallow basins of around 75 cm. This radius may be increased gradually up to 150 cm after the third year. Care should be taken not to spill the inorganic fertilizers on the trunk, branches or leaves of young trees in order to avoid burning.

h. Plant protection in cocoa

Pests and diseases are important risks to the productivity and the quality of harvests which in turn affects the returns to the farmers. Since cocoa is an introduced crop the more important for farmer is to be clear about the pests and diseases and be able to identify the symptoms correctly. The main pest of cocoa in Indonesia are cocoa pod borer (CPB), Helopeltis sp., Zeuzera, while the disease are vascular streak dieback (VSD), pod rot (P. Palmivora).

Mealy bugs (*Planococcus lilacinus, Planococcus citri, Paracoccus marginatus*) are pests that mostly attack cocoa plants. They colonize on the tender parts of the plants such as the growing tips of the shoots, the terminal buds, the flower cushions, the young cherelles and mature pods. The feeding of mealy bugs induces cherelle wilt (Figure 2.4).

(a) (b)

Figure 2.4. Mealy bugs. (a) *Planococcus lilacinus;* (b) *Paracoccus marginatus*

Seedling blight (*Phytophthora palmivora*) and black pod rot (*Phytophthora palmivora)* are diseases commonly found in cocoa trees. The symptom of seedling blight develops on the leaves and stem of seedlings or budded plants. On leaves, small water-soaked lesions appear which later coalesce in the blighting of leaves. On the stem, water-soaked lesions develop initially and later turn to black colour. Stem infections develop any point on the stem causing the death of seedlings. Further, infection of black pod rot (Figure 2.5) appears as chocolate brown spots, spreading rapidly and soon occupying the entire pod surface. As the disease advances, a whitish growth of fungus (fungal sporangia) is produced over the affected pod surface. Ultimately, the affected pods turn brown to black, then the internal tissues and the beans become discolored. The beans in the infected pods approaching ripeness may escape infection because they are separated from the husk on ripenin.

Figure 2.5. Black pod rot (*Phytophthora palmivora)*

Non-insect pests, such as rats (*Rattus rattus*) and squirrels (*Funambulus trisriatus* and *F. palmarum*), are the major rodent pests of cocoa. They cause serious damage to the pods. The rats usually gnaw the pods near the stalk portion, whereas squirrels gnaw the pods in the center (Figure 2.6).

(a) (b)

Figure 2.6. Non-insect pests. (a) Rat damage; (b) Squirrel damage

2.2. Life Cycle Assessment Application in Agriculture Sector

Life cycle assessment (LCA) methods are described in a series of the ISO 14000 environmental management standards. It is a tool for evaluating the effects that a product or a process has on the environment over the entire period of its life. The life cycle of a product includes its extraction and processing of the raw material from which it is made, its manufacturing, packaging and marketing processes, its use, reuse, its maintenance, its eventual recycling, and its disposal as waste at the end of its useful life (ISO, 2006).

Initially developed for assessing the environmental impacts of industrial plants and production process, LCA applications have been extensively applied in the agricultural sector with some adaptations of classical LCA's in term of the boundary system, functional units, and environmental impact categories of agriculture (Haas et al., 2000; van der Werf and Petit, 2002; Brentrup et al., 2003). The recent research on LCA application in the agricultural sector are presented in Table 1.1.

An LCA study consists of four sequential components: goal definition and scoping, inventory analysis, impact assessment and interpretation (Figure 2.7). Goal definition and scoping requires the mapping of the intended application, the reason for the study, the intended audience, the functional unit and system boundaries. Inventory analysis involves compilation and quantification of inputs and outputs throughout the life cycle. Impact assessment evaluates the magnitude and significance of potential environmental impacts of a product system. Interpretation combines the findings of the inventory analysis and impact assessment in order to draw conclusions and present recommendations.

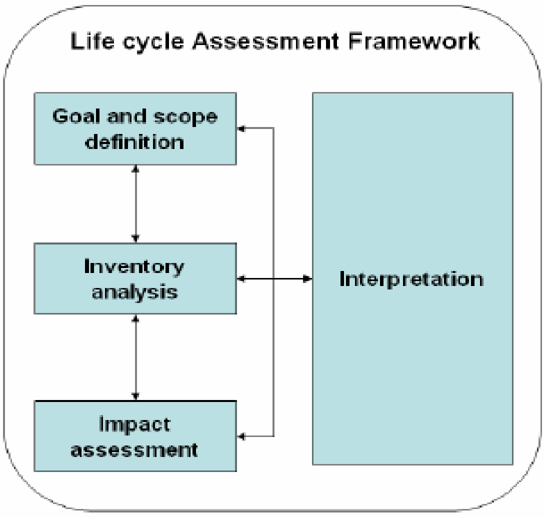


Figure 2.7. Life cycle assessment framework (from ISO 14040 Standards)

2.2.1. Goal Definition and Scoping

The goal and scope definition phase defines the statement of the study purpose and its intended use, description of the system to be studied and definition of the system boundary, the functional unit and the identification of data quality requirements, as well as the assumptions and the limitations of the study.

The system boundary of a system is often illustrated by a general input and output flow diagram. All operations that contribute to the life cycle of the product, process, or activity fall within the system boundaries. The purpose of the functional unit (FU) is to provide a reference unit to which the inventory data are normalized.

The definition of FU depends on the environmental impact category and aims of the investigation. The FU is often based on the mass of the product under study. However, nutritional and economic values of products and land area are also being used. One of the important characteristics in the LCA applied to agriculture is the use of plural functional units at the same time and discusses its differences (Haas et al., 2001).

2.2.2. Life Cycle Inventory Analysis

This phase is the most work intensive and time consuming of all the phases in an LCA, mainly because of data collection. The data collection can be less time consuming if good databases are available and if customers and suppliers are willing to help. Many LCA databases exist and can normally be bought together with LCA software. Data on transport, extraction of raw materials, processing of materials, production of usually used products such as plastic and cardboard, and disposal can normally be found in an LCA database. Data from databases can be used for processes that are not product specific, such as general data on the production of electricity, coal or packaging. For product-specific data, site-specific data are required. The data should include all inputs and outputs from the processes. Inputs are energy (renewable and non-renewable), water, raw materials, etc. Outputs are the products and co-products, and emission (CO_2, CH_4, SO_2, NO_x and CO) to air, water and soil (total suspended solids, biological oxygen demand, chemical oxygen demand, and chlorinated organic compounds) and solid waste generation (municipal solid waste and landfills).

2.2.3. Life Cycle Impact Assessment

The life cycle impact assessment (LCIA) aims to understand and evaluate environmental impacts based on the inventory analysis within the framework of the goal and scope of the study. In this phase, the inventory results are assigned to different impact categories, based on the expected types of impacts on the environment. This research uses ReCiPe2008 as A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level (Goedkoop, et al, 2013).

LCIA generally consists of the following elements: classification, characterization, normalization and valuation. Classification is the process of the assignment and the initial aggregation of the LCI data into common impact groups. Characterization is the assessment of the magnitude of potential impacts of each inventory flow into its corresponding environmental impact (e.g., modeling the potential impact of CO_2 and CH_4 on global warming). Characterization provides a way to directly compare the LCI results within each category. Characterization factors are referred to as equivalency factors. Normalization expresses potential impacts in ways that can be compared (e.g., comparing the global warming impact of CO_2 and CH_4 for the two options). Valuation is the assessment of the relative importance of environmental burdens identified in the classification, characterization, and normalization stages by assigning them weighting which allows them to be compared or aggregated. Impact categories include global effects (global warming, ozone depletion, etc.); regional effects (acidification, eutrophication, photo-oxidant formation, etc.); and local effects (nuisance, working conditions, effects of hazardous waste, effects of solid waste, etc.).

Originally, LCA was not considered as a site specific assessment, because agriculture has to be considered as site-specific. The impact categories considered as the central environmental impacts of agriculture differ from the classical LCA's product, process and production system of enterprises (Table 1.2). For instance, the impact on biodiversity, landscape image and animal welfare, topics that have high public awareness and are governed by the agro-environmental policies of the European Union have to be taken into account (Haas et al., 2001).

2.2.4. Interpretation

The purpose of an LCA is to draw conclusions that can support a decision or can provide a readily understandable result. The inventory and impact assessment results are discussed together in the case of an LCIA, or the inventory only in the case of LCI analysis, and significant environmental issues are identified for conclusions and recommendations consistent with the goal and scope of the study. This is a systematic technique to identify and quantify, check and evaluate information from the results of the LCI and LCIA, and communicate them effectively. This assessment may include both quantitative and qualitative measures of improvement, such as changes in product, process and activity design; raw material use, industrial processing, consumer use and waste management.

CHAPTER 3
METHODOLOGY

3.1. Location of the Study

This research for the environmental performance of 1 tonne cocoa pod production from cocoa monoculture and cocoa agroforestry was carried out in the rain-fed cocoa farms belonging to the national estate plantation company by having a field supervisor from The Indonesian Coffee and Cocoa Research Institute (ICCRI). There were five representative cocoa farms evaluated in Banyuwangi, East Java Province, Indonesia. The cocoa farms were purposively selected, with Criollo as selected cocoa cultivar.

(a) (b) (c)

Figure 3.1. Cocoa cultivation in the area of study: (a) Monoculture, (b) Cocoa-coconut agroforestry and (c) Cocoa-rubber agroforestry

The five farms included 1 plot of cocoa monoculture, 2 plots of cocoa-coconut agroforestry and 2 plots of cocoa-rubber agroforestry. The model of cocoa-agroforestry selected in this study follows the definition of sequential or row agroforestry. The plot of cocoa monoculture is full-sun-grown cocoa intercropped with *Leucaena sp* and *Gliricidia sepium*, previously a shifting cultivation farm. Cocoa agroforestry is comprised of 2 plots of a simple agroforestry system with shade-grown cocoa intercropped beneath planted fruit trees of coconut, and 2 plots of shade-grown cocoa beneath a well-developed secondary rubber forest canopy (Figure 3.1). The plot of cocoa monoculture in this research was used as standard of plantation practice which has existed for long time in Indonesia, and then to be compared with the plots of cocoa-coconut agroforestry and cocoa-rubber agroforestry.

Having purposively selected cocoa cultivation under the same enterprise's management in a single district will benefit in minimizing spatial variability. In addition, having focus on specific cultivar of Criollo cocoa will reduce cultivation practices variability. Considering the economic value of cocoa yield, this study selected Criollo cocoa. Known as a fine or flavour cocoa, Criollo cocoa has a premium selling price in the market, compared to bulk or ordinary cocoa from other cultivars of Forastero, Trinitario and Nacional. In the chocolate industry, fermented Criollo beans are utilized to enhance chocolate flavour even finer. However, Criollo cultivar is not disease-resistant, making it scarce in the market. Criollo cocoa cultivation requires intensive crop maintenance and protection, including higher application of fertilizer and chemicals controls. Given that condition, only big plantation companies cultivate Criollo cocoa in Indonesia.

3.2. Survey Design, Data Collection and Inventory

The data collection procedure involved a literature review and a purposive field survey of cocoa farmers and related stakeholders. The field survey was carried out in the period of January to April 2014. Emissions due to resource and energy usage were quantified using estimation methods. The data collected was converted to values that relate to the functional unit. In short, the data analysis included materials and energy inputs and outputs of cocoa cultivation as presented in Figure 3.2. The result of this inventory was used for life cycle impact assessment and interpretation.

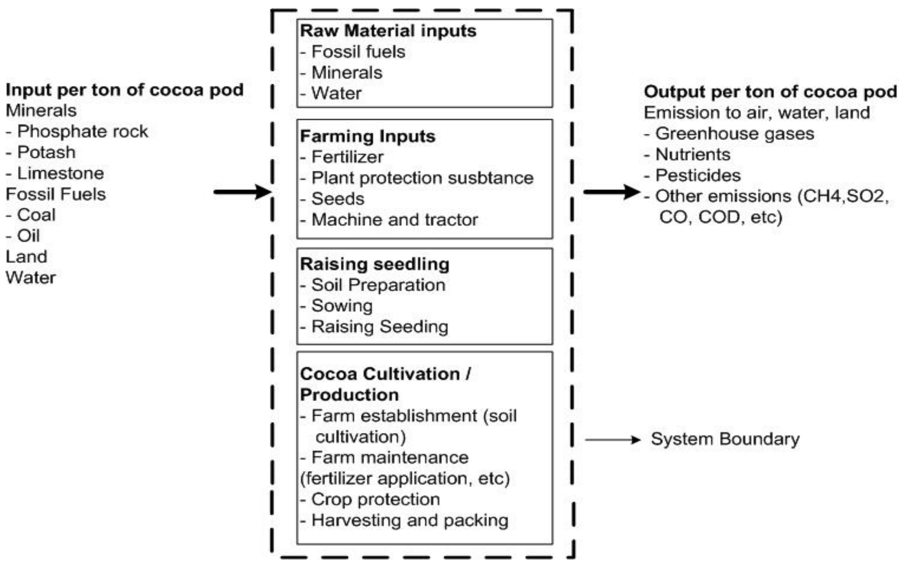


Figure 3.2. System boundary, relevant inputs-outputs of cocoa pod

3.2.1. Literature Review

Some information was collected from related resources and the literature. Data and information to be collected included (but not limited to) cocoa plantation, product output, materials and energy inputs, background data on production and application of fertilizer, emission reference, etc.

Apart from primary data collection, secondary data that support this research were gathered. Records of energy use, electricity, fertilizers and agrochemicals substance application, and other related data were collected from the company. For instance, precipitation data was taken from the local meteorological stations in Banyuwangi Regency, Indonesia. Some information was also retrieved from other resources and literature in order to compare the results obtained in the field survey.

3.2.2. Field Data Collection

The face-to-face interview technique with a structured questionnaire was used to collect the field data. The object of the survey was the field managers of cocoa plantations under study, researchers from ICCRI and other respective persons intended to secure the data availability and quality in the field. Some on-site measurements to collect primary data of environmental conditions were also undertaken, such as ambient climatic data, soil quality and waste water quality on each plot of cocoa cultivation.

(a) (b) (c)

Figure 3.3. Some field equipment; (a) Hygro meter; (b) Light meter; (c) Hand auger

Some equipment to support field measurement was required (Figure 3.3). For instance, to measure ambient climatic condition, light meters, hygro meters, and global positioning systems (GPS) were utilized. Ambient climatic data, such as, the temperature and the relative humidity in each plot, were measured by means of a data logger. The light intensity per cocoa plot was measured by a digital light meter (Lutron model LX-103) 0–50000 Lux with 3 ranges under standardized conditions.

Soil samples at each plots of study were collected with respect to the purpose of soil fertility measurements by composing a number of samples from the surface layer of the soil. Location of the sampling points was georeferenced by using a GPS, and different samples of soil (sampled to a fixed depth 0-30 cm) at each plot of cocoa cultivation were collected by using hand auger, then mixed into composite sample that represents soil from the cocoa plantation at particular model (monoculture and agroforestry). Soil samples were analyzed in the laboratory to get properties of soil fertility, such as carbon content, nitrogen content, and soil microbes.

3.2.3. Methods of Analysis

a. Climate Data

Climate data compilation from 1960 until 2006 from climatology stations at the study area were retrieved from international and national reliable climate database source, such as Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation (APHRODITE). The data was then analyzed by using software of Arcview Geographical Information System to produce an illustration of precipitation map as well as Microsoft Excel to support a simple forecasting method over 5 years from the current year.

One of climate data analyzed in this study is precipitation. It is the fundamental factor that controls the formation and persistence of drought conditions. It also becomes a significant variables to be considered in agriculture sector. During drought period farmers will not perform nursery activity, seedling as well as fertilization. Given this, drought monitoring systems are fundamental tools in managing the risks connect to agricultural production. Monitoring is normally carried out using drought indices, one of which is Standardized Precipitation Index (SPI).

The Standardized Precipitation Index is a probability index that considers only precipitation. The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI index may be computed with different time steps (e.g. 1, 3, 6, 12 months).

The SPI is defined for each of the above time scales as the difference between the monthly precipitation (*x*) and the mean value (*μ*), divided by the standard deviation (*σ*):

$$SPI = \frac{X - \mu}{\sigma} \quad (1)$$

where:

SPI : Standardized precipitation index

x : Precipitation value (e.g. 1 month, 3 months, 6 months, 12 months)

μ : mean value

σ : Standard deviation

Table 3.1. Categorization of standardized precipitation index SPI

Drought Class	Class Definition	SPI
3	Extremely Wet	≥2
2	Very Wet	1.5 to 1.99
1	Moderately Wet	1 to 1.49
0	Normal	-0.99 to0.99
-1	Moderately dry	-1 to-1.49
-2	Severely dry	-1.5 to-1.99
-3	Extremely dry	≤-2

b. Soil Quality Data

b.1. Carbon, Nitrogen and Soil Organic Matter (SOM)

Carbon (C) and Nitrogen (N) analysis were analyzed based on wet oxidation method, which applies oxidation of organic matter by potassium dichromate ($K_2Cr_2O_7$) in the presence of sulfuric acid (H_2SO_4). Dilution of sulfuric acid provides heating for oxidation reaction (temperature up to approximate 1000C), but only part of the organic matter in the soil sample (on average 75%) will be reached by the potassium dichromate.

Soil organic matter (SOM) has been defined as the organic fraction of the soil exclusive of undecayed plant and animal residues and has been used synonymously with humus (Rosell et al., 2001). SOM content is usually estimated from the analysis of soil organic carbon (SOC). Soil organic carbon is often viewed as the most important indicator of soil quality because of its impact on physical, chemical and biological indicators of soil quality (Reeves, 1997). Furthermore, SOM has already been suggested as an indicator for soil quality in previous LCIA methodologies, generally as a measure of soil attributes to be combined with other parameters. SOM can be used as a single indicator for life support function (LSF) in the framework of LCIA for agricultural land uses (Milà i Canals et al., 2007).

Carbon is the main element present in SOM, comprising 48-60% of the total weight. Organic carbon determination is often used as the basis for SOM estimation. Many researchers suggested a conversion factor of 1.724 multiplied by measured organic carbon value to estimate SOM (Magdoff et al., 1996; Brady and Weil, 1999; Kerven et al., 2000). The conversion factor of 1.724, which is the so-called Van Bemmelen factor, is the result of attributing 58% to the content of organic carbon in the organic matter in any soil.

In general, the quantity of SOM in a system can be: (a) measured directly from soil samples, (b) calculated using local datasets and locally adjusted models, and (c) estimated values from the literature for different areas and crops. Soil organic matter can be expressed as concentration (%) or as quantity per unit of land surface (Mg ha^{-1}). The conversion of organic matter requires the soil bulk density (g of soil/cm^3) and the thickness (cm) of the soil horizon. In many soil surveys, agricultural soils are sampled from 0 to 20 cm in one single soil horizon. In this case, calculation of the quantity of the organic carbon pool in the first 20 cm would follow the equation:

$$SOM_{0\text{-}20\ cm}\ (Mg\ ha^{-1}) = C\ (\%) \times \text{Bulk density}\ (g\ cm^{-3}) \times \text{Soil depth}\ (cm) \qquad (2)$$

If the soil has been sampled and analyzed divided in *i* different horizons this calculation step should be carried out for each soil horizon as indicated by the following equation:

$$SOM_{total} = \sum_{n=1} (\%\ C_i \times \text{Bulk density}\ i \times \text{Horizon thickness}\ i) \qquad (3)$$

b.1. Soil Microbes

Colony-forming units (CFU) of microorganisms in soil samples are counted using the dilution plate technique. Plate count is an interpretation of an approximation of the number of microbe cells (colonies) present in the plate. One gram of a sieved fresh soil sample is shaken for 10 min in 100 mL sterile tap water and subsequently diluted to give dilutions of $1{:}10^3$ to $1{:}10^6$. The suspensions obtained are pipetted into Petri dishes and mixed with solidifying cultivation media. All media are sterilized by autoclaving. Only two groups of soil microorganisms are counted in the sample, bacteria and fungi. CFU is a measure of viable bacterial or fungal cells. In direct microscopic counts (cell counting using haemocyto-meter) where all cells, dead and living, are counted, but CFU measures only viable cells (Balestra and Misaghi, 1997). As only an estimate of the number of cells present, CFU can be a best estimate as the only cells able to form colonies are those that can grow under the conditions of the test (e.g., incubation media, temperature, time, and oxygen conditions).

3.2.4. Justifications for Field Data Collection

A productive period of twenty five years for the cocoa was considered for this study. Thus, it was initially assumed that each rotation lasts for twenty five years after which the plantation will be re-established. Inputs material and energy were accounted during the cocoa cultivation at farm level, such as those for tree seedlings and for establishing the cocoa trees (pegging, digging holes and planting), as seen in Figure 3.2. To support data collection, reference data from literature about inputs of energy and material were also utilized, particularly data related to farm establishment and cocoa cultivation.

The first four years of cultivation were considered as the establishment phase of the cocoa crop. Cocoa closes its canopy in about the sixth or seventh year. After this period, all operations undertaken were assumed to be relatively same until the end of the productive life of the crop for which is estimated to be twenty five years. However, yield of cocoa pod may fluctuate given certain conditions, as such disease and pest outbreak due to long run of drought in certain year at study area. As Criollo cocoa is a less-resistant cultivar, such condition was taken into account in the assessment. The cocoa yield pattern was estimated based on field data collected within the latest 3 years from sample of plots of cocoa cultivation under the study, namely cocoa monoculture and cocoa agroforestry.

3.3. Impact Assessment

The LCIA calculates the likely human and ecological effects of material consumption and environmental releases identified during the LCI step. The inventory data are multiplied by characterization factors (CF) to give indicators for the so-called environmental impact categories with the following equation.

Impact category indicator $i := \sum_j (Ej \text{ or } Rj) \times CFi,j$ (4)

Where impact category indicator i = indicator value per functional unit for impact category i; Ej or Rj = release of emission j or consumption of resource j per functional unit; CFi,j =

characterization factor for emission *j* or resource *j* contributing to impact category *i*. The characterization factors represent the potential of a single emission or resource consumption to contribute to the respective impact category. For selected impact categories, such as analyses on global and regional impact categories of global warming, acidifying and eutrophication was carried out by using ReCiPe2008 as a life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level (Goedkoop et al., 2013). All indicator results under each impact category in particular for global and regional impacts are summed to result in an overall impact score for the impact category. Table 3.2 gives the list of impact categories that will be accounted for in this study.

Table 3.2. List of impact categories investigated

General distinction	**Impact Category**
Input related categories	Impact of land use (sub category : loss of life support function-SOM)
Output related categories	Climate change (global warming) Acidification Eutrophication
* Other	Economic profitability of cocoa plantation

3.3.1. Impact of Land Use

Impacts of land use category covers a range of consequences of human land use. A distinction has been made between use of land with impacts on the resource aspect and use of land with impacts on life support functions.

(1). Loss of Life Support Function (LSF)

In this sub-impact category, the problems defined are the effects on the life support function resulting from interventions, such as harvesting biotic resources, or the destruction or alteration of land. Given the discussion on characterization of land-use-related impact categories of LSF is far from settled, this study will use soil organic matter (SOM) as LSF indicator (Milà i Canals et al., 2007), which considers SOM as a robust indicator for soil quality. Even though it does not fully consider all aspects of soil functioning, SOM is an appropriate LSF indicator for most agricultural soils because their SOM levels correlate with general soil quality and its related LSF. Further, SOM has been often recognized as the best stand-alone indicator for soil quality.

3.3.2. Climate Change

Climate change is defined as the impact of human emissions on the radiative forcing (i.e. heat radiation absorption) of the atmosphere. This may in turn have adverse impacts on ecosystem health, human health and material welfare. Most of these emissions enhance radiative forcing, causing the temperature at the Earth's surface to rise. This is popularly referred to as the 'greenhouse effect'. The areas of protection are human health, the natural environment and the man-made environment.

3.3.3. Acidification

Acidifying pollutants have a wide variety of impacts on soil, groundwater, surface waters, biological organisms, ecosystems and materials (buildings). Examples include fish mortality in lakes, forest decline and the crumbling of building materials. The major acidifying pollutants are SO_2, NO_x, and $NH_{3.}$ Areas of protection are the natural environment, the man-made environment, human health and natural resources.

3.3.4. Eutrophication

Eutrophication covers all potential impacts of excessively high environmental levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In addition, high nutrient concentrations may also render surface waters unacceptable as a source of drinking water. In aquatic ecosystems, increased biomass production may lead to a depressed oxygen level, because of the additional consumption of oxygen in biomass decomposition (measured as BOD, biological oxygen demand). As emissions of degradable organic matter have a similar impact, such emissions are also treated under the impact category eutrophication. The areas of protection are the natural environment, natural resources and the man-made environment.

3.3.5. Economic Productivity of Cocoa Plantations

The profitability of multispecies systems is firstly related to their productivity. Despite difficulties due to the number of products involved, specific tools have been developed to assess that productivity. The most widely used method for evaluating the yield advantage of intercropping is the land equivalent ratio (LER), defined as the total land area required under mono-culture cropping to give the yields obtained in the poly-culture cropping system (Mead and Willey, 1980). The LER concept has been extended to take into account the duration of land occupancy by crops (Area × Time Equivalence Ratio, ATER) or to incorporate monetary returns (Monetary equivalent ratio, MER).

LER compares the yields obtained by growing two or more species together with yields obtained by growing the same crops as pure stands. For two mixed species, the LER equation is as follows:

LER = mixed yield1/pure yield1 + mixed yield2/pure yield2 (5)

The resulting LER indicates that the amount of land needed to grow both species together compared to the amount of land needed to grow pure stands of each. An LER greater than 1.0 indicates mixed systems are advantageous, whereas a LER less than 1.0 shows a yield disadvantage. The null hypothesis (LER=1) means that inter- and intra specific interactions are equivalent. The properties of multispecies systems are not always derivable from the properties of individual species. Collective dynamics may lead to emergent properties that cannot be deduced from species properties alone, i.e. redistribution of the soil-water resource by shrubs in agroforestry systems. This makes it more complicated to define a proper methodology for studying multispecies systems compared with studies involving one species (Malézieux et al., 2009)

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1. General Description of Study Area

The areas of cocoa cultivation plots under this study are located in 3 (three) different sub-districts: Kali Kempit, Kali Rejo and Kali Telepak, Banyuwangi, Indonesia. Afdeling Margosugih at Kali Kempit district is located at 08°19’S latitude, 114°04’E longitude and an altitude of 340 meters above sea level (asl). This site has flat topography (0-8°) with soil type ranging from latosol and alluvial. Afdeling Pegudangan at Kali Rejo district is located at 08°22’S latitude, 114°04’E longitude and an altitude of 440-625m asl. The site has a plain steep as well as hilly (25-45°) topography with predominantly latosol soil type. Afdeling Porolinggo at Kali Telepak district is located at 08°23’S latitude, 114°06’E longitude and an altitude of 100-150m asl. The site has flat topography (0-8°) with latosol and alluvial as the predominant soil type.

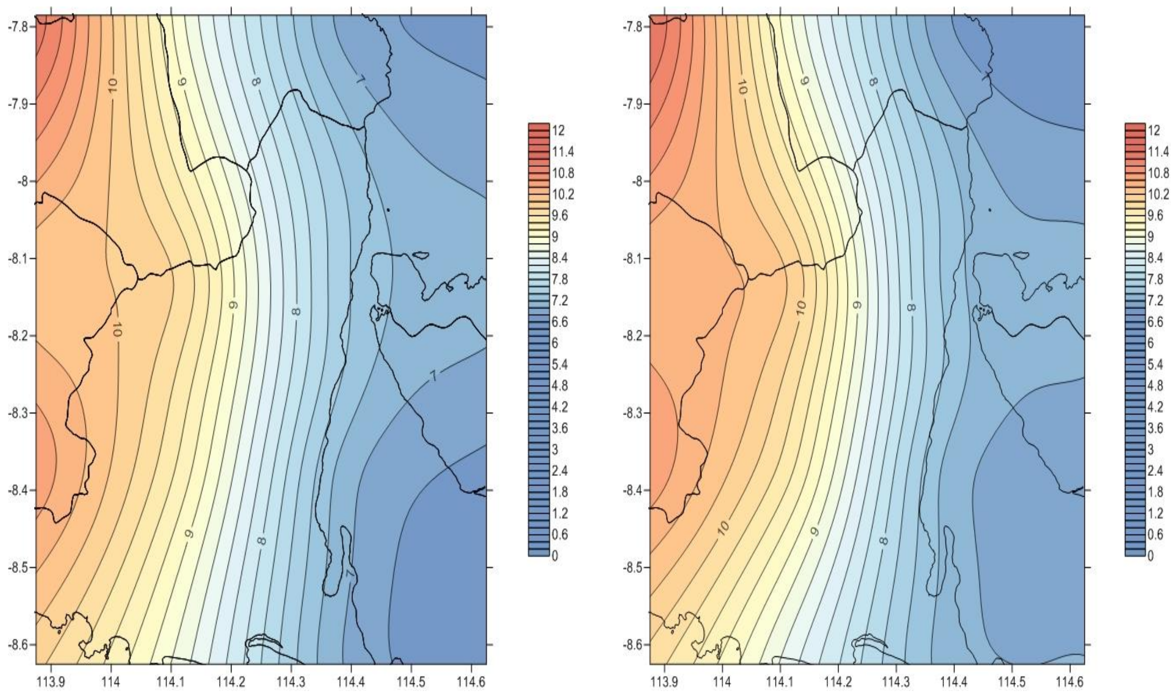
In general, the climate type at the plots in this study is characterized by type C, based on Schmidt-Ferguson’s climate classification that refers to a somewhat wet region. Further analysis on meteorological data obtained from the latest period of 2001 – 2013 results that biophysical characteristics of the study area has an annual average temperature of 26.5°C and relative humidity of 84.6 % and a mean monthly rainfall ranging between 40.8–257 mm.

The distribution mode of precipitation will influence the pattern of cocoa cultivation, especially the activity of nursery, seed planting, fertilization, crop protection and water irrigation. Fertilization schedule to cocoa trees for instance is performed twice per year, one at the beginning and another at the end of raining season. This is to anticipate nutrient competition between the emergence of flush and flowering period. Water adequacy during rainy session will help to dissolve nutrient and nutrient uptake by plant’s roots. During dry seasons water pump will be operated to provide fresh water from the ground. Therefore, understanding the precipitation cycle in the region will help the company and cocoa farmers in managing better cocoa cultivation.

As shown in precipitation map for 1960-2006 (Figure 4.1), the result analysis of monthly precipitation at regions where this research takes place suggests that the precipitation level increases during the months of November - April, while the level falls in

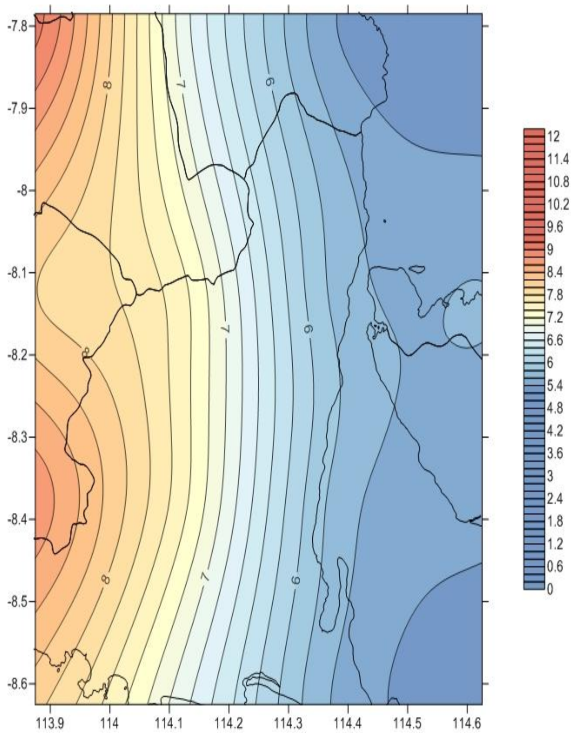
May - October. Despite having long duration of rainfall month, the regions commonly experience a short period of rainfall, with high intensity and spreading over the region. These phenomena occur on May and October. Degree of precipitation in regions where are close to Hindia Ocean and Bali Strait is also influenced by variability of surface water temperatures in the nearby waters. Taking account this result analysis, as fertilization schedule is applied in the beginning and in the end of raining seasons, then it suggests fertilizer inputs to cocoa farm can be planned on between April – May and October - November.

As cocoa plants are sensitive to drought, the company provides adequate water availability to the cocoa farm during the period of December- February. Most cocoa plantations at the area of study depend on rain-fed; installment of water pump equipment becomes an option to irrigate the cocoa plantation. Anticipating water shortage, Afdeling of Margo Sugih at Kali Kempit district for instance, operates water pumps equipped with generator set all days, once in three days to irrigate cocoa cultivation area (77.28 ha for cocoa-coconut plantation and 50.80 ha for cocoa-rubber plantation).

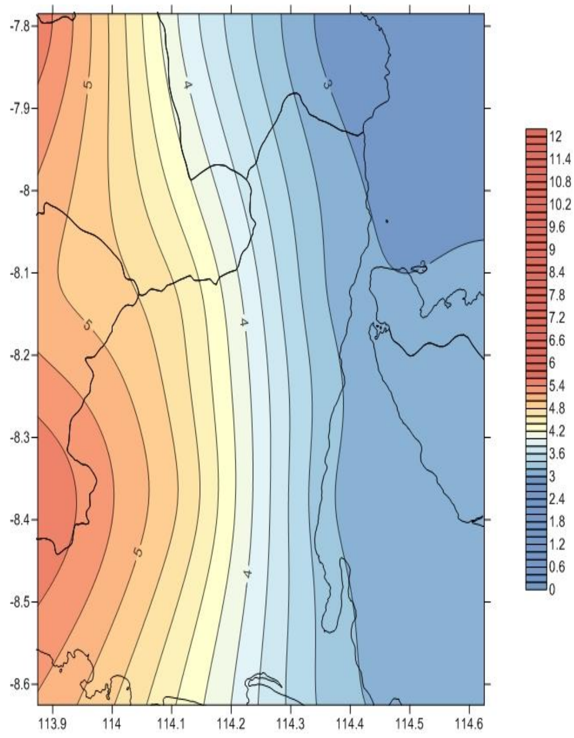


a. January

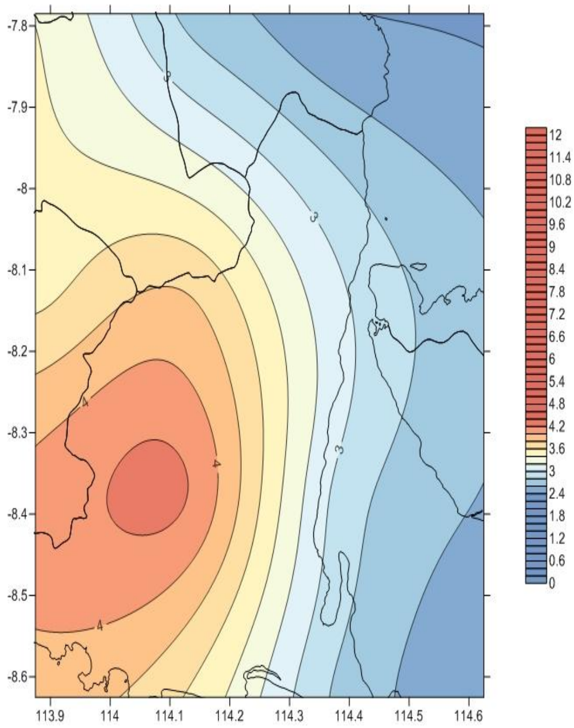
b. Februari



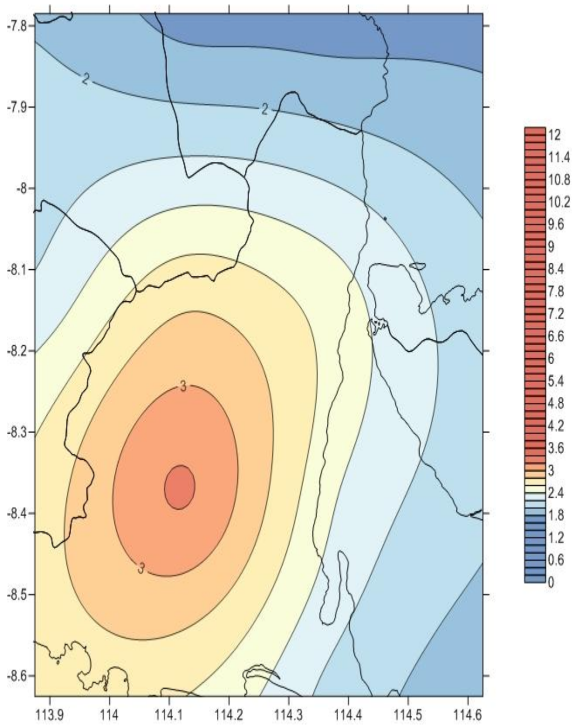
c. March



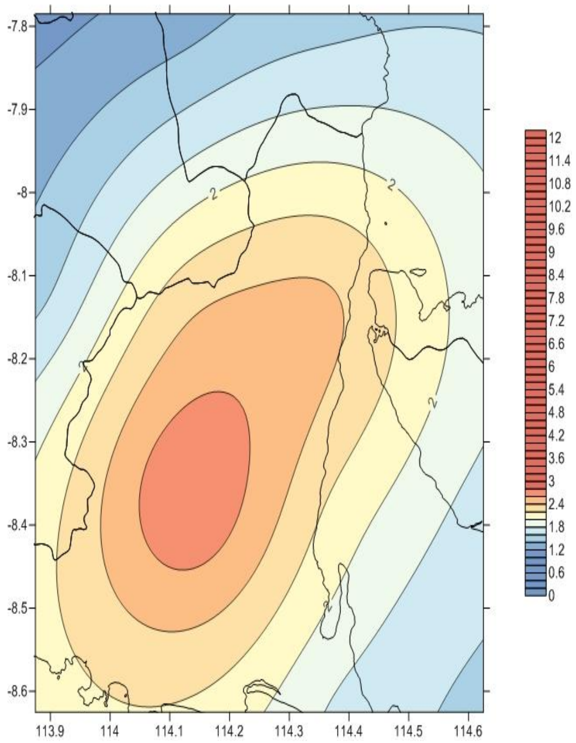
d. April



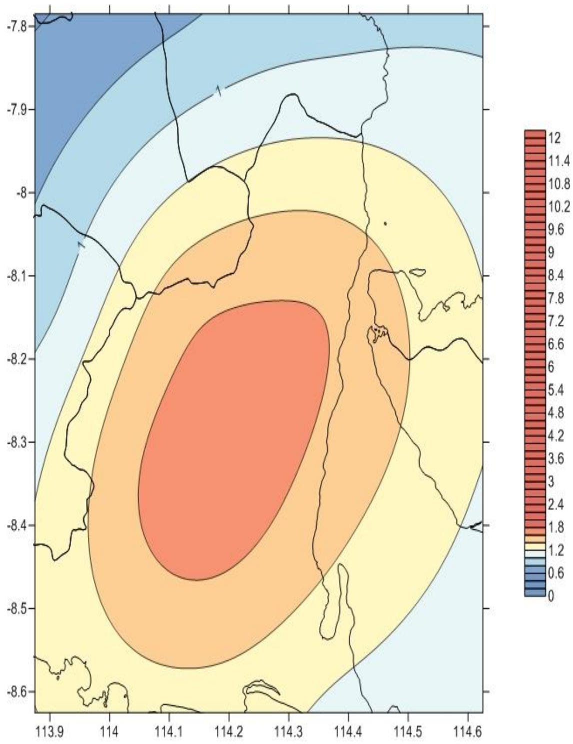
e. May



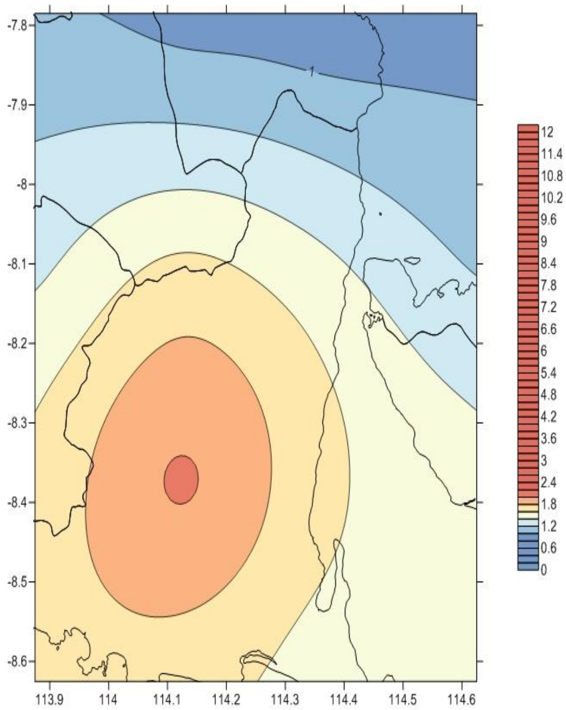
f. June



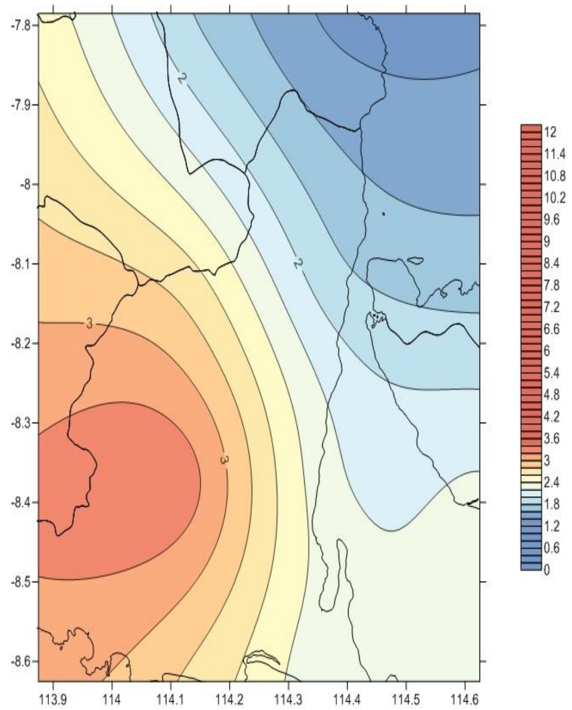
g. July



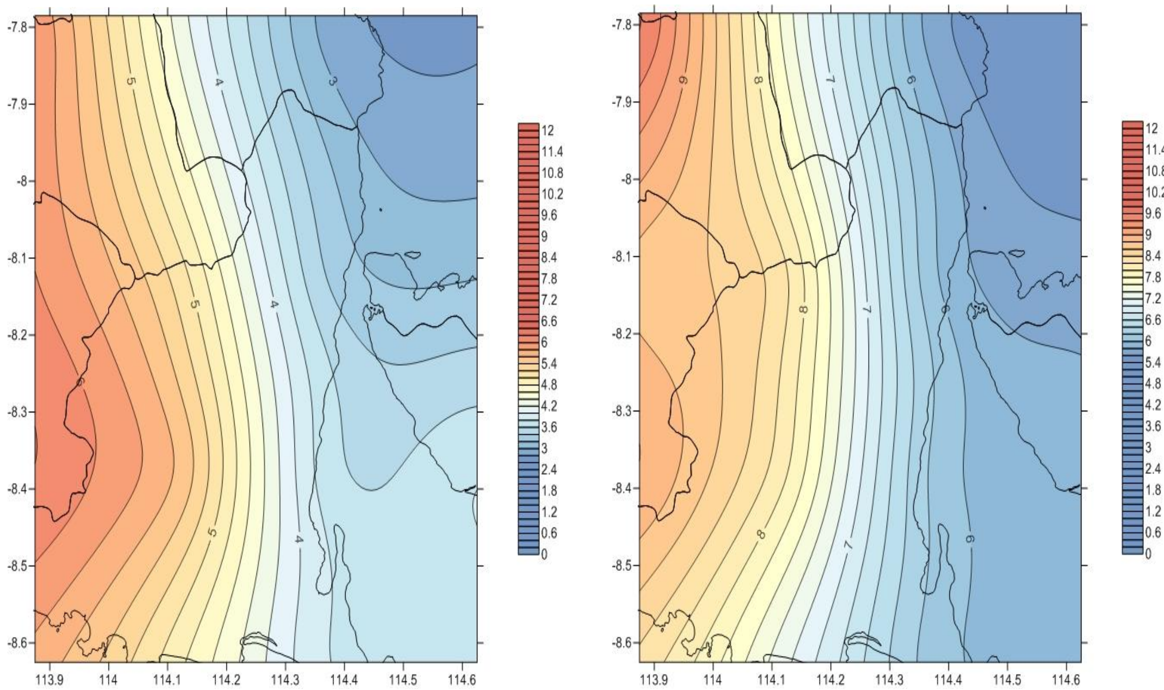
h. August



i. September



j. October



k. November l. December

Source: Precipitation date retrieved from Asian Precipitation-Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE), 2014.

Figure 4.1. Monthly precipitation map recorded from 4 climate stations for period of 1960-2006 in Banyuwangi regency

Cocoa is highly sensitive to changes in climate, therefore understanding climatic conditions at the cultivation area will be helpful for farmers in dealing with good practice of cocoa cultivation. Given attention that the study area is close to Hindia Ocean and Bali Strait, it needs further analysis to observe anomalous dry and wet years over the last year period which was carried out in this study by using SPI analysis. Such observation helps to figure out the extreme condition of drought due to variability of surface water temperature and the occurrence of El Niño-Southern Oscillation as fluctuations in temperature between the ocean and atmosphere.

The annual precipitation at the study area ranges between 1,123-2,715 mm yr^{-1}. The results of the SPI analysis suggest that the study area had moderately dry seasons occurring in almost every year. As seen in Figure 4.2, condition of wet years happened only in 2010 and 2013 as indicated by SPI-12 value to be moderately and extremely wet year consecutively. The rest of the years were considered as drought, by which 2002 and 2006 became moderately dry year.

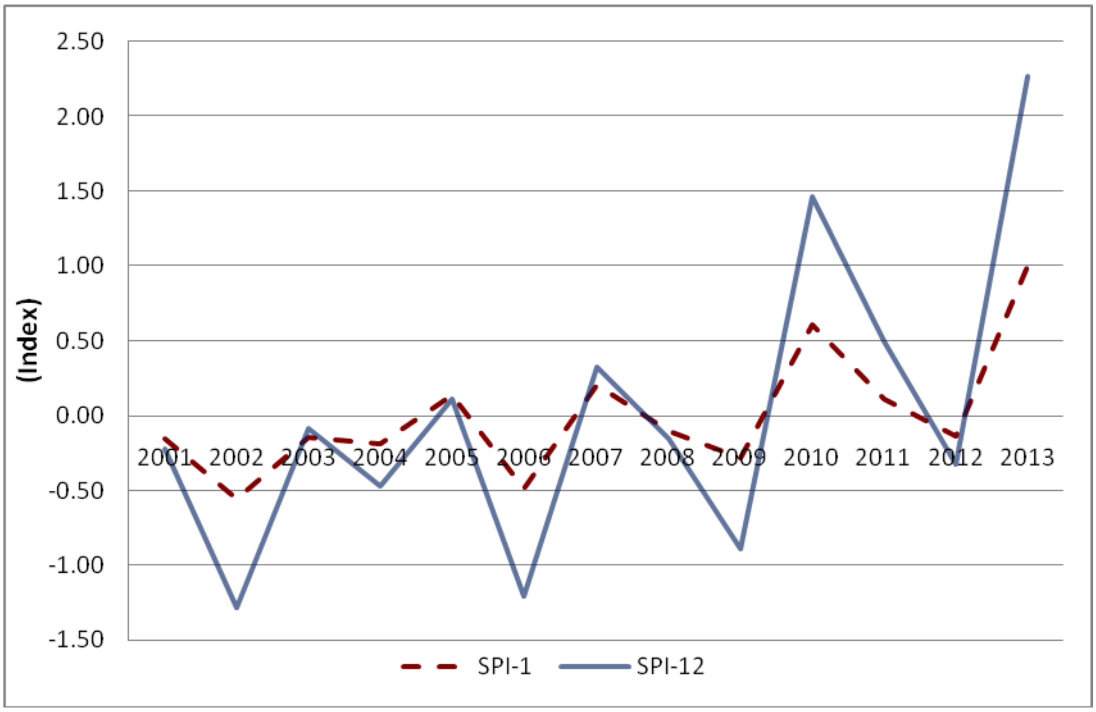


Figure 4.2. The 1 and 12 months SPI at the study area

The awareness of climate and its impact on cocoa farms include activities ranging from the time of planting cocoa to the time of harvesting and drying cocoa beans in order to achieve the target cocoa yield. Some studies suggested that there are significant relationships found between cocoa flower production and climatic factors namely temperature, light intensity and rainfall, by which rainfall was found to have the greatest influence on the phenological cycle of the cocoa plant. In addition, climate could influence stages and rates of development of cocoa pests and pathogens.

Adjaloo et al. (2012) for instance stated that flowering, especially on the trunk was highest in the rainiest months. This may be due to intrinsic factors namely: genetic and physiological factors which appear to play a large role in the phenological behavior of t,he cocoa plant. Their study also informed that in Ghana the production of new pods or cherelles increased during the major rainy season (June, July, August), but was evenly distributed from the minor to the dry season. Production of small and medium pods peaked in August whereas production of large pods peaked in October.

4.2.Cultivation Practice and Ambient Climate in Each Cocoa Plot

All cocoa plantation plots in this study we managed by different subsidiaries of the company. The practice of cocoa cultivation performed by each subsidiary refers to the company's annual guideline of cultivation procedure. The guideline is set annually in the previous year by considering market demand, annual production target of company, on-site (field) condition and other critical issues as such environment and social, and will be implemented in the following year's cultivation activities.

Understanding the cultivar of cocoa as well as the principles of cocoa planting, typical shade trees, other crops and trees cultivated within the cocoa cultivation boundary would facilitate the estimation of the input and output of any materials, energy and resources utilized during the whole cycle of cocoa pod production. For instance, this study investigated the practice of Criollo cocoa cultivation in the form of monoculture and agroforestry. Criollo cocoa produces fruits (cocoa pods) with thick, white or pinkish seeds that yield more flavored seeds and fine chocolate. However, Criollo cultivar is not frequently cultivated because of its high susceptibility to diseases. Given these concerns, Criollo cultivar cultivation in Indonesia commonly belongs to large plantation companies (estate plantation). The company has enough capacity and resource to maintenance Criollo plantation in order to diversify yield with premium fine cocoa product.

The basic principle of cocoa planting is that cocoa will be cultivated in association with other plants and/or trees to provide shade. Traditionally, cocoa is cultivated under the shade of a selectively thinned forest and might represent one of the oldest agroforestry systems in tropical America. This system is a special kind of agroforestry in which the under-storey is drastically suppressed to introduce cocoa and the density of upper storey trees is reduced. At the first stage of the cocoa farm establishment, the company arranges planting holes for cocoa whether it will be cultivated in monoculture or agroforestry. The field findings of cocoa planting at the company can be described as follows.

4.2.1. Cultivation at Cocoa-Monoculture Plot

The field study at the cocoa monoculture plot (plot-1) found that the company had applied a spacing model of 3m × 3m for cocoa planting. Species of shading trees the company commonly plant are *Leucaena sp* and *Gliricidia sepium,* which are also planted under the same spacing model as cocoa planting, 3m × 3m. Shading trees are grown in a horizontal line. The planting scenario is expected to provide 1 shading tree for 4 cocoa trees. These shading trees will be planted at the first or second year earlier than the schedule of cocoa planting. An illustrative planting model for cocoa monoculture can be seen in Figure 4.3.

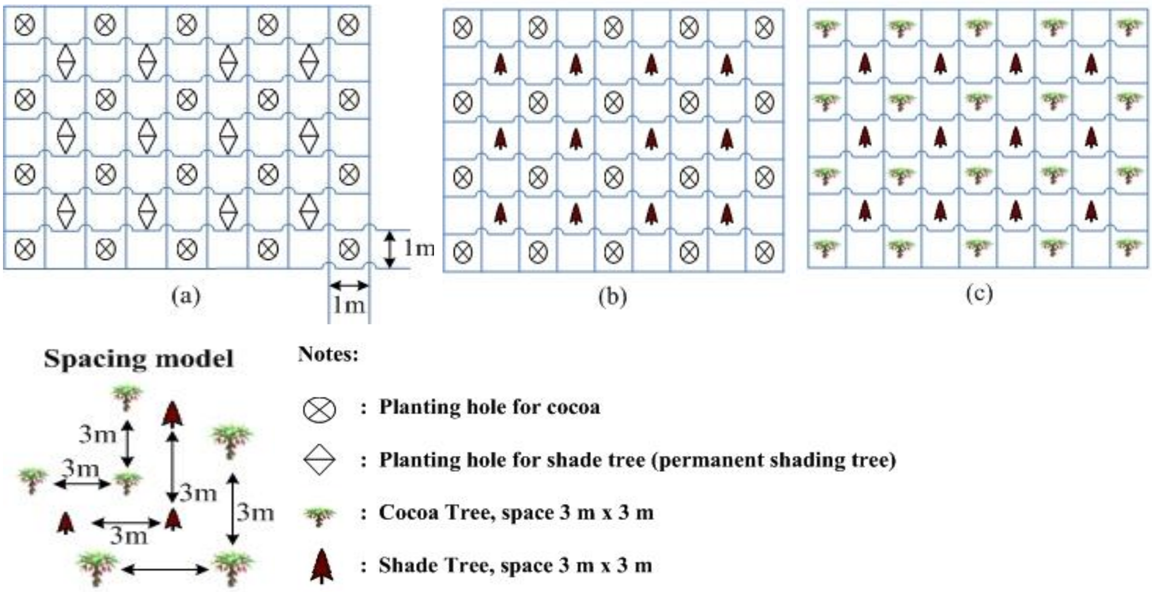


Figure 4.3. (a) Planting layout for cocoa and shading tree; (b) the 1st - 2nd year of shading tree planting; (c) the 3rd- 4th year of cocoa planting.

The existence of *Leucaena sp* will bring benefits for cocoa cultivation. As a thornless long-lived shrub or tree, *Leucaena sp* may grow to heights of 7-18 m, which is sufficient to provide shade to mature cocoa trees. As highly nutritious forage tree, it can also provide firewood, timber, green manure and erosion control. It is commonly used in tropical agroforestry systems, by which the low seeding varieties are used to provide shade for cocoa and support for climbers such as pepper and vanilla. *Leucaena* hedges are useful as windbreaks and firebreaks.

As the commercial cocoa stands, 3.0m × 3.0m spacing with density of 1100 - 1200 cocoa trees ha^{-1} is quite commonly established by the company. This is based on the model production system of the cocoa region in Indonesia, which is considered to be a standard of conventional planting density in order to maximize the cocoa yield.

To ensure adequate plant stand in the cocoa monoculture, a higher seed rate was used at sowing and excess plants were a later removed to maintain the required cocoa plant population. Cocoa seeds were planted in the rainy season. At the first stage, the estimated number of seeds to be planted by the company was 1265 stands with 4-6-month old seedlings or grafted or budded plants. Field investigation in the plot of cocoa monoculture found that crops were established at high planting density; with an approximate number 1100 cocoa trees, excluding the existence of shading tress.

(a) (b)

Figure 4.4. Nursery farm (a) *Leucaena sp* seedlings and (b) Cocoa seedlings

Fertilization planning is performed twice per year, at the beginning and the end of rainy season. Although depending on rain-fed for cocoa tree watering, the company used water pump equipment to irrigate the cocoa farm during the dry season, operated once at 3-day intervals. Spraying will be performed based on the presence of pest or insects in the cultivation area. However, intensive spraying is a measure that is commonly established by the company due to pest and disease outbreak during dry season.

(a) (b)

Figure 4.5. Pesticide spraying (a) Spraying equipment (b) Spraying activity

4.2.2. Cultivation at Cocoa-Agroforestry Plot

The planting model for cocoa agroforestry by the company is relatively the same planting model as that for cocoa monoculture. Model of sequential or row agroforestry is currently implemented by the company to plots of cocoa cultivation under this study. The company introduces coconut (*Cocos nucifera*) and rubber (*Hevea braziliensis*) as main crop that are planted in between cocoa trees as well as other shading trees. Instead of having cocoa pod produce, the cultivation of cocoa-agroforestry aims at diversifying products (co-products of coconut sap and raw latex) and minimizing the use of agrochemicals.

a. Cocoa- Coconut Agroforestry (Plot-3 and Plot-4)

Two plots of cocoa coconut agroforestry were investigated in this study and located in Kali Kempit and Kali Telepak districts. The first plot at Kali Telepak has applied spacing model of 3.0 m × 3.0 m for both cocoa and shade tree planting (*Leucaena sp),* and model of 9.0 m × 12.0 m for coconut planting. Spacing pattern for the first plot of cocoa agroforestry is slightly different from the second plot at Kali Kempit, which has applied 3.0 m × 4.0 m for both cocoa and shade tree planting, and 15.0 m × 18.0 m for coconut planting. However, planting system for each crop at these two plots is the same. Coconut trees will be firstly planted in the 1^{st} – 2^{nd} years, then shading trees in the 3^{rd} -4^{th} years. Both coconut trees and shading trees are cultivated in a horizontal line. The latest planting schedule is cocoa, planted in the 5^{th} year. An illustrative planting model of cocoa-coconut agroforestry can be seen in Figure 4.6.

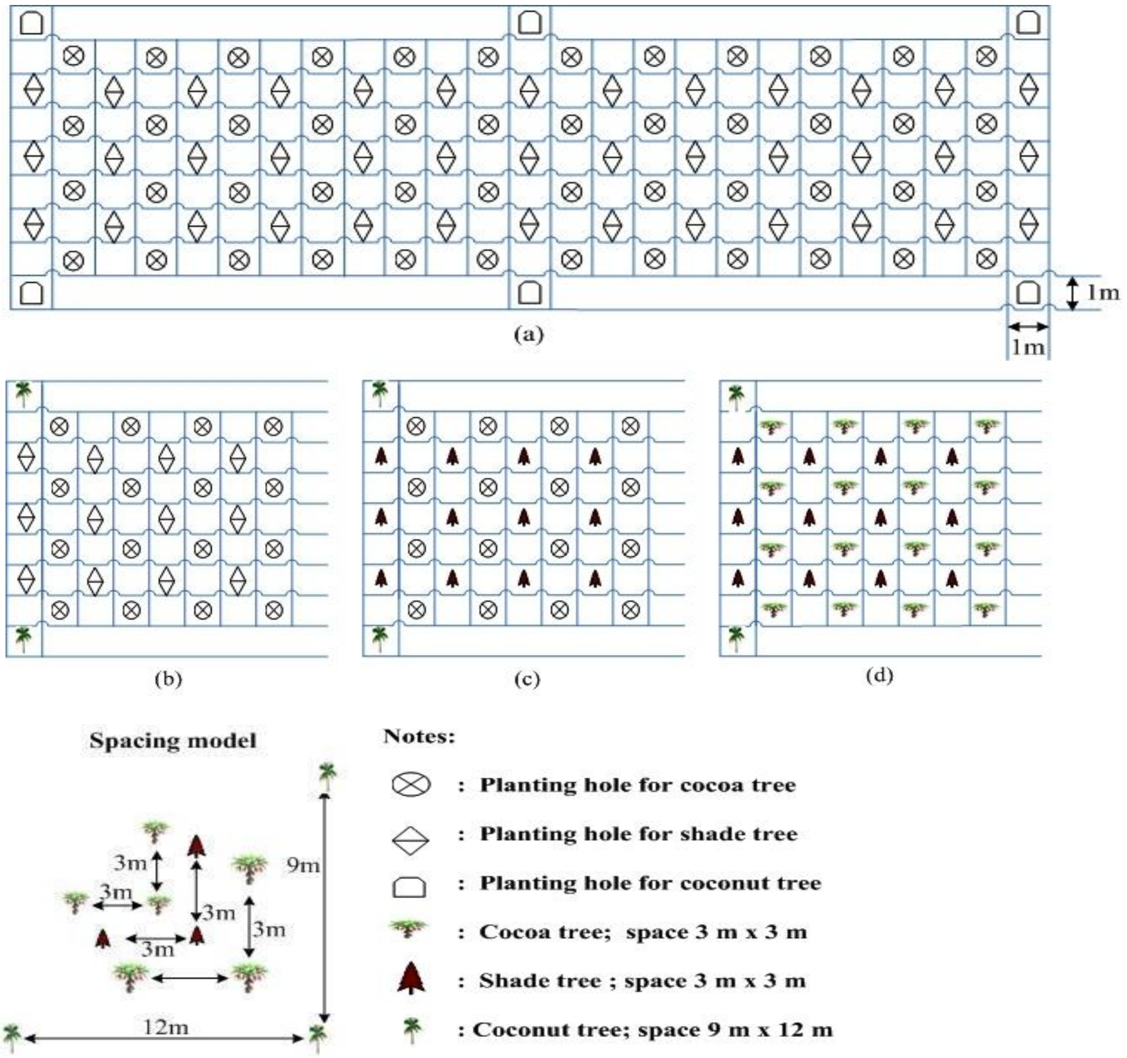


Figure 4.6. (a) Planting layout for cocoa, coconut and shading tree; (b) The 1st-2nd years of coconut planting, (c) The 3rd-4th years of shading tree planting, (d) The 5-6th years of cocoa planting.

Activities of farm maintenance and crop protection in cocoa coconut agroforesty are intensified only for cocoa trees as the main commercial crop. In general, the activities of farm maintenance and crop protection for cocoa trees are relatively the same activities as performed in cocoa monoculture. However, coconut trees are relatively less treated, especially during the mature period. Agro chemical inputs for instance were only applied for coconut seeds planting at the 1st- 2nd year as well as during period of coconut growth at the 3rd and 4th year (vegetative stage) of planting schedule. The company will not perform further crop maintenance for coconut at mature period. At this stage, coconut trees already act as permanent shading tree in the boundary of management system for cocoa coconut agroforestry and produce coconut sap as co-product.

Field investigations of the plots of cocoa coconut agroforestry found the crops were established at low planting densities. Cocoa coconut agroforestry in the first plot accounted for about 650 cocoa trees ha^{-1} and 104 coconut trees ha^{-1}, while the second plot were about 720 cocoa trees ha^{-1} and 57 coconut trees ha^{-1}. Given the existence of coconut trees with spacing 9.0m × 12.0m, the density of cocoa tree within 1 ha area becomes lower comparable to cocoa monoculture.

b. Cocoa-Rubber Agroforestry (Plot-4 and Plot-5)

The practice of cocoa-rubber agroforestry was introduced to the company's commercial plantation since 2007/2008, made by either transplanting unproductive cocoa trees with commercial trees, or by starting cocoa-rubber agroforestry at the beginning stages of cultivation. There are two plots of cocoa rubber agroforestry investigated in this study, and located in the sub-districts of Kali Kempit and Kali Rejo.

The first plot at Kali Kempit applied a spacing model of 3.0m × 3.0m for both cocoa and shade tree planting (*Leucaena sp).* Rubber tree has planting space of 3.0m × 4.0m which is cultivated into separate block, consisting only two rows of rubber trees in vertical line. Distance between cocoa block and rubber block is 4.5m. Spacing pattern for the first plot of cocoa rubber agroforestry differs from the second plot at Kali Rejo, which has applied planting space 4.0m × 3.0m for both cocoa and shade tree, and 3.0m × 4.0m for rubber planting. Distance between cocoa block and rubber block at the second plot is 5.0m.

The planting schedule of rubber and shading trees were in the 1st - 2nd years and then cocoa trees in the 3rd - 4th years. In general, plots of cocoa rubber agroforestry are established at medium planting densities. The density of cocoa rubber agroforestry in the first plot accounts for about 450 cocoa trees ha^{-1} and 200 rubber trees ha^{-1}, while the second plot are about 675 cocoa trees ha^{-1} and 270 rubber trees ha^{-1}. An illustrative planting model of cocoa-rubber agroforestry is presented in Figure 4.7.

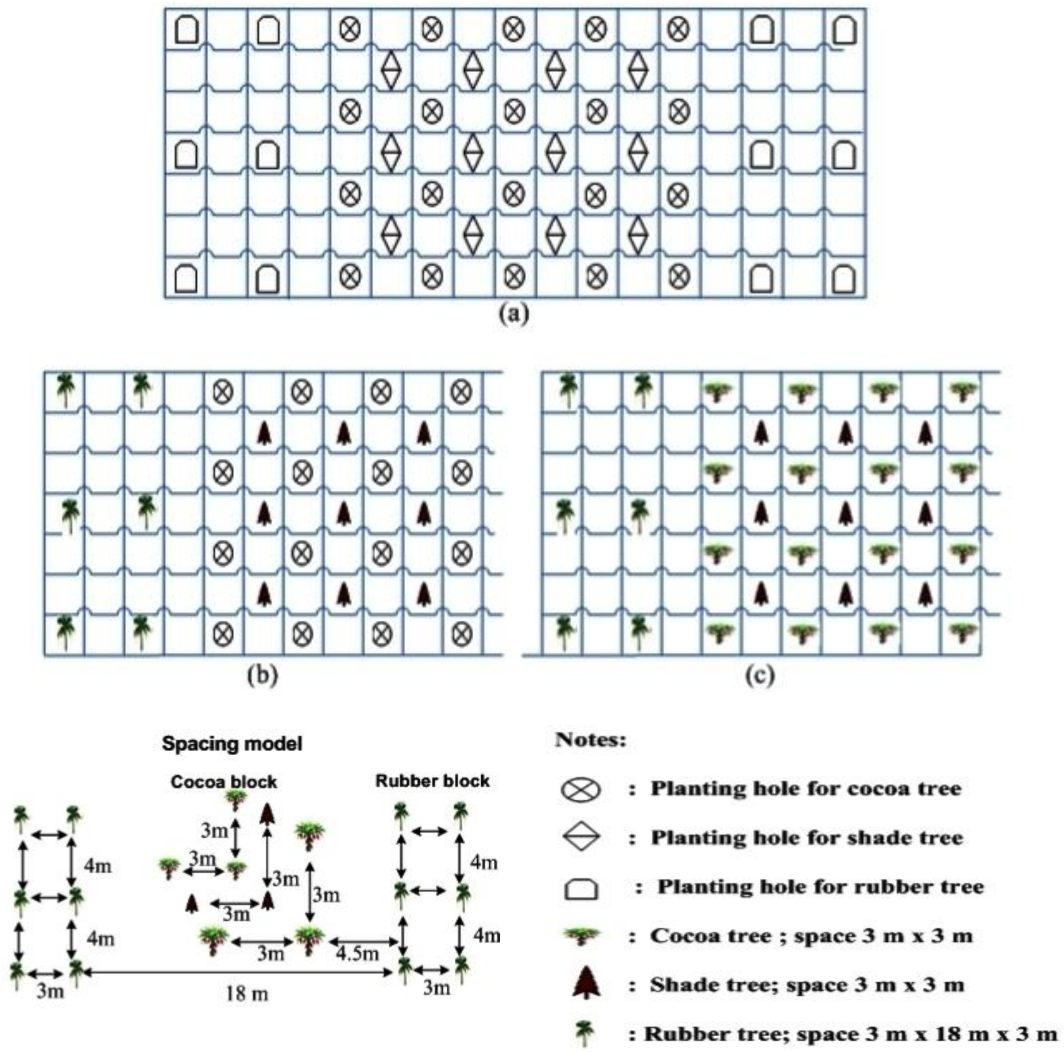


Figure 4.7. (a) Planting layout for cocoa, rubber and shading tree; (b) the 1st - 2nd years of rubber and shading tree planting (c) the 3rd - 4th years of cocoa planting.

Activities of farm maintenance and crop protection in cocoa rubber agroforesty are intensified for both cocoa and rubber trees as commercial crops. This differs from the activities of cocoa coconut agroforestry which treats less to coconut trees. Agrochemical inputs are applied to the cocoa and rubber trees during whole cycle life of the management system for cocoa rubber agroforestry where raw latex is co-product of the system.

4.2.3. Ambient Climatic Condition at Each Plot

Field investigations found that planting density influences the ambient climatic condition at each plot, as shown in Figure 4.8. Ambient condition measurements at plot of cocoa monoculture showed that an average temperature of 29.5 °C, relative humidity of 81.25 % and a light intensity range from 59 to 231 lux. As compared to ambient conditions at plots of cocoa monoculture, plots of cocoa agro forestry have higher temperature value, lower relative moisture content and higher range of light intensity.

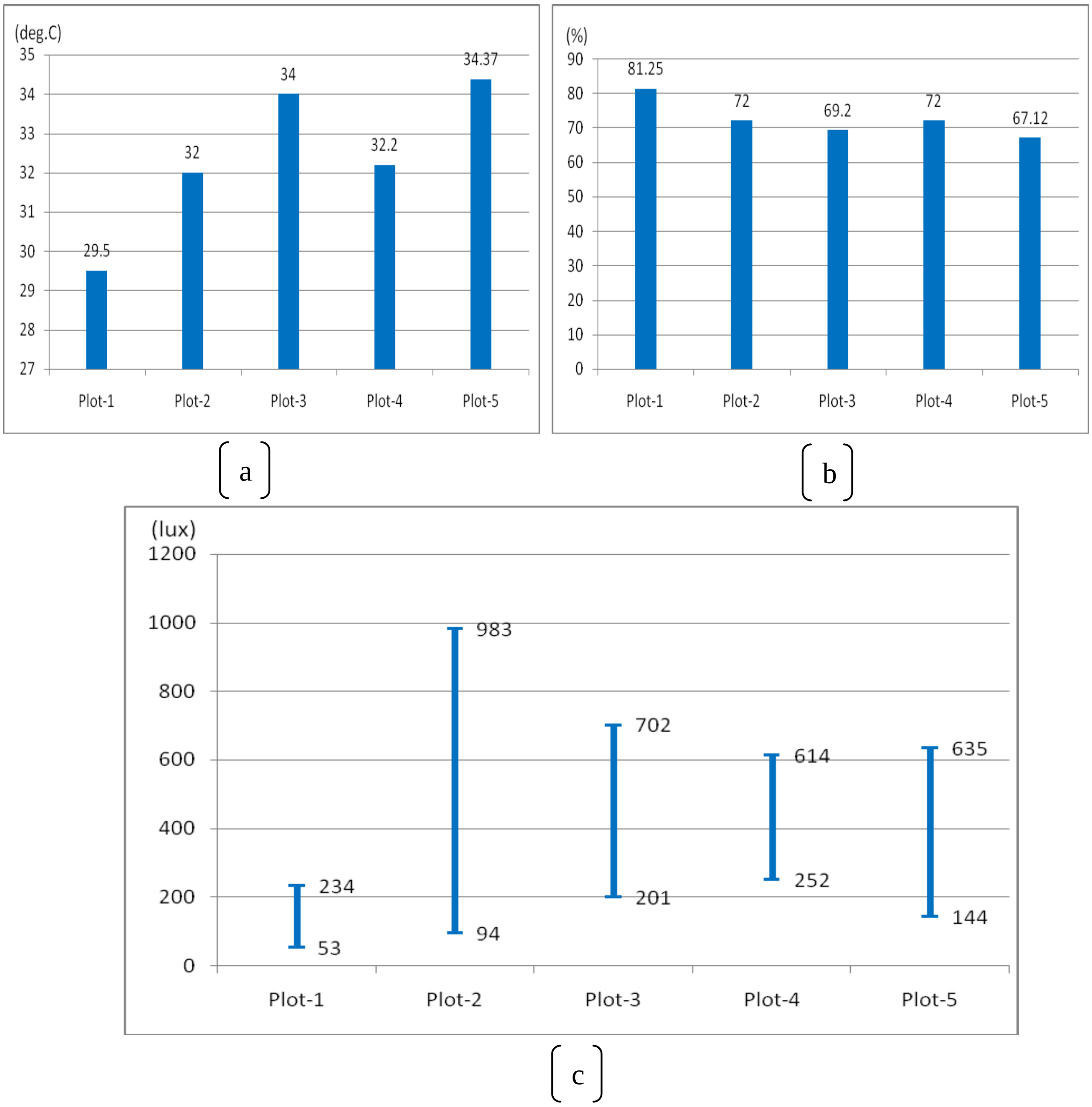


Figure 4.8. Ambient climatic conditions at each plot: (a) Temperature; (b) Relative moisture; and (c) Range of light intensity.

Maintaining optimal ambient climatic conditions in the plantation area provides a better environment for cocoa and other crops to grow and produce an expected yield, while at the same time minimizes potential disease outbreak. According to research in Nigeria, it suggested that a combination of optimal temperature (29°C), relative humidity (74%) and minimal rainfall (1,125 mm) will give a better yield and reduce black pod incidence on cocoa produced (Lawal and Emaku, 2007). In addition, Anim-Kwapong and Frimpong (2005) confirmed that black pod disease is the most destructive of a number of diseases, which attack the developing or ripening cocoa pod. The disease is closely related to weather and climate. In Ghana, it is more prevalent in damp situations and is most destructive in years when the short dry period from July to August is very wet.

4.3. Environmental Performance of Cocoa Production

To understand environmental burdens and benefits resulting from different practices of cocoa cultivation either from monoculture or agroforestry systems, in depth investigations and analyze were performed. Details of the results are presented below.

4.3.1. Global and Regional Impacts

a. Global Warming

Can be noticed from Figure 4.9 that plot -2 and plot-3 representing cocoa-coconut agroforestry have the lowest contribution of environmental impact of global warming than do plot-1 representing cocoa monoculture and plot-4 and plot-5 representing cocoa-rubber agroforestry. Each plot-2 and plot-3 has 3.49E+01 kg CO_2-eq and 3.85E+01 kg CO_2-eq. This is as result of minimized use of fertilizer and agrochemicals to crop maintenance as well as to control pest and decease during cocoa pod production at those two plots of cocoa-coconut agroforestry.

The analysis reveals that fertilizer and pesticide utilization is a major cause of the environmental burdens, particularly impact on global warming. Due to indirect process, such as the extraction and production of fuel and materials to produce fertilizer and agrochemicals and direct process as result of application of fertilizer and pesticide to cocoa cultivation, the concentration of released greenhouse gases such as CO_2, CH_4, N_2O were increased in the atmosphere. Such accumulation contributes to global warming potential.

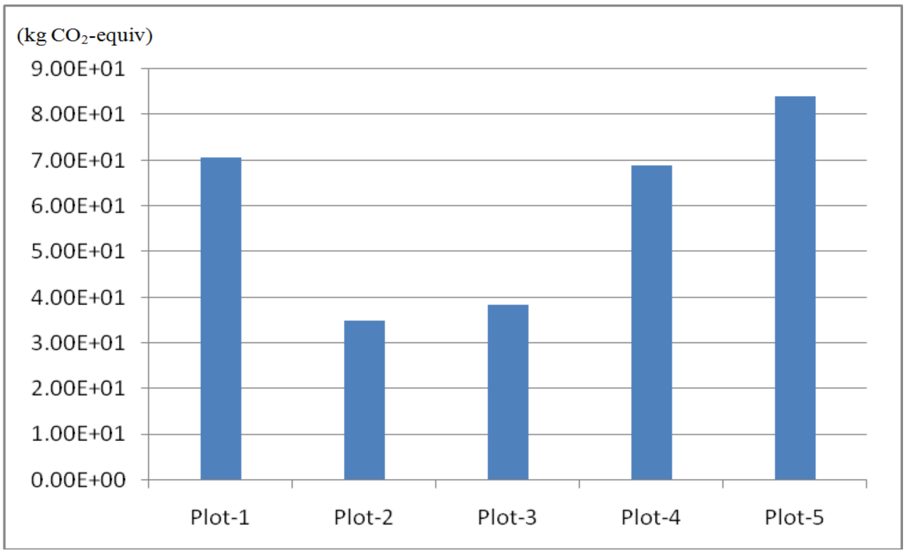


Figure 4.9. Global warming impact potential for 1 tonne cocoa pod production

The utilization of agrochemical substances is commonly applied in the agricultural sector, including in cocoa agricultural production systems to increase the cocoa yield. Cocoa cultivation relies heavily on the use of fertilizers and agrochemical substances in order to increase the cocoa yield and protect the healthy condition of cocoa fruit. When cultivating Criollo cultivar for instance (this cocoa cultivar is as main focus of this study), the input of agrochemicals seems to increase as compared to cultivating other cultivars. As Criollo cocoa is not disease-resistant, it requires strict treatment and maintenance that make it hard for household farmers to grow and keep it healthy. Only big estate plantations companies afford to cultivate Criollo in Indonesia because they have sufficient capacity and resources. Although Criollo cocoa needs intensive crop maintenance, the companies expect to gain higher economic return from cultivation Criollo cocoa

On the contrary, the environmental burden of potential global warming for cocoa-rubber agroforestry is slightly higher than for cocoa monoculture. Plot-4 and plot-5 of cocoa-rubber consecutively have 6.90E+01 kg CO_2-eq and 8.41E+02 kg CO_2-eq. This result might be as result of higher agrochemical input utilized for both cocoa and rubber trees maintenance. Such increasing input eventually occurs at phase of mature period (generative stage) in order to provide sufficient nutrients to keep crops healthy.

b. Acidification

Considering the potential impact of acidification on the environment, cocoa-coconut agroforestry (plot-2 and plot-3) has the least contribution to this impact than do other plots (Figure 4.10). Expressed in SO^2-equivalents, the contribution of plot-2 and plot-3 to acidification is 4.19E-02kg SO_2-eq and 4.42E-02 kg SO_2-eq consecutively.

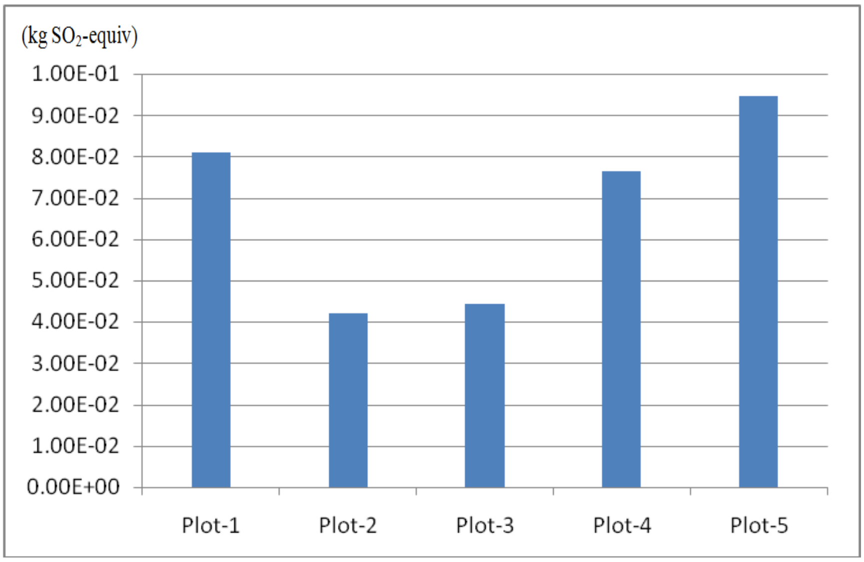


Figure 4.10. Acidification impact potential for 1 tonne cocoa pod production

The effect of potential acidification emissions depends on the deposition pattern (fate) and the susceptibility of the receiving area to acidification (e.g. buffer capacity and $CaCO_3$-content) (Brentrup et al., 2002). Comparing the acidification potential of nitrogen oxide (NO_x) for instance, as the use of fertilizer containing nitrogen mineral (e.g. urea fertilizer) was minimized at cocoa-coconut agroforestry so that the potential excess of nitrogen material in the form of nitrous oxide was limited. When there is an excess of mineral nitrogen from urea fertilizer in the soil, microbial activity can produce nitrous oxide under certain conditions. The amount of mineral nitrogen converted to nitrous oxide depends on many factors, for example the initial form of the nitrogen, supply of organic material, temperature, soil moisture and oxygen supply. Excess nitrogen in cultivated soil also causes nitrogen leaching to groundwater or runoff water. A certain proportion of nitrogen leaching out with the runoff water can volatilize as nitrous oxide, giving indirect emissions of the gas.

Air emissions of nitrogen oxide can also be derived from fuel combustion processes in agricultural machine and vehicles. Here, fuel is utilized to run an irrigation generator set during the dry season, which commonly starts in November – April, becomes one of major sources. Based on site visit and field personnel interview, it was known that during drought seasons water pumps equipped with generator set were operated almost all days, once in three days to irrigate cocoa plantation.

c. Eutrophication

Eutrophication brings consequences to environmental impacts by which in the agricultural stages (cultivation), the main issues of increasing impacts are due to the increasing use of water and agrochemicals, such as fertilizers and pesticides (including insecticides, fungicides, etc). As production and use of fertilizers and pesticides becoming a major cause of the environmental burdens in the cocoa production stage, the excess of these materials released to surrounding water body of environment will also bring negative impacts. Eutrophication is mainly caused by leakage of nutrients during cultivation and emission of phosphates from the production of phosphorus fertilizers. Therefore improvement measures should focus on reducing fertilizers and pesticides usage.

In cocoa-coconut agroforestry, the reduced density of cocoa trees has also minimized the utilization of agrochemicals without compensating the cocoa yield produced. Field investigations at plots of cocoa-coconut cultivation practice found that agrochemicals were applied at minimum levels at both the vegetative and generative stages. Cocoa trees at plots of cocoa-coconut agroforestry were maintained relatively similar as at the cocoa monoculture. The existence of coconut trees in the plots also did not need high inputs of agrochemical, even required less inputs in the generative stage. Shortly, the company provides less treatment and few inputs for coconut trees which are intercropped with cocoa trees. Given this condition, the potential impact of eutrophication affected by cocoa-coconut agroforestry might reach at minimum. This can be confirmed by the result analysis of two plots (plot-2 and plot-3) of cocoa-coconut agroforestry which posed the less contribution to eutrophication by 1.96E-05 kg PO_4 -eq and 2.53E-05kg PO_4 -eq, as compared to other plots (Figure 4.11).

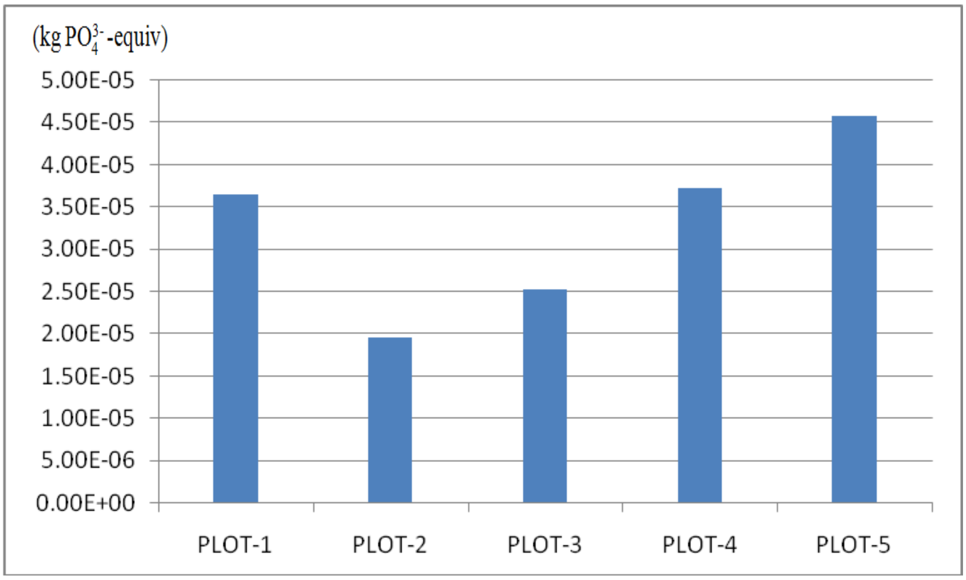


Figure 4.11. Eutrophication potential impact for 1 tonne cocoa pod production

d. Summary of findings for environmental performance on global and regional impacts

Despite variability in the productivity affected by rainfall and the degree of crop maintenance, the application of fertilizers and other agrochemicals in cocoa monoculture has improved the soil quality and was able to slow down the rate of cocoa tree mortality. As there is no crop competition in the system, the input of fertilizer and agrochemical can result in higher yields of cocoa pod production.

In the case of cocoa-rubber agroforestry plots, soil fertility cannot be maintained due to crop competition. When rubber trees are grown in the side row of cocoa crop, the cocoa yield tends to decline pursuant to nutrient and soil quality loss. Known as having good capacity to grow by expanding canopy and below ground by its roots, fertilization to rubber trees will encourage the proliferation of fine roots and root density so that indirectly increases competitiveness to cocoa crops. Further, the fact that space between cocoa and rubber rows was not sufficiently wide will affect nutrient competition. In the first two years, rubber roots will grow gradually and concentrates around 2.0m in the bole of rubber tree. By about seven years, rubber roots are able to explore into the space of cocoa crop under standard spacing and at this stage the roots of each crops are possibly intermingled (Pathiratna and Perera, 2003).

Pathiratna (2006) also suggested that intercrops grown under immature rubber are virtually unaffected by competition as the inter-row spaces receive sufficient light and the interference from rubber roots is low at this stage. But when rubber trees mature canopies close and rubber roots spread into the inter row space interfering the growth and yield of intercrops. The combined effect of both these factors will be envisaged as competition, affecting the performance of intercropping rubber trees.

Based on the above conditions, to produce 1 tonne cocoa pod cocoa-rubber agroforestry eventually requires the highest inputs of fertilizer and agrochemicals. The increased inputs are intended to replace nutrients lost in the area of cocoa-rubber agroforestry plots as result of crop competition as well as to maintain target of cocoa yield production. As consequences, global environmental impacts attributed to the crops maintenance activities in cocoa-rubber agroforestry performed the highest then other agricultural systems under this study (Table 4.1).

Table 4.1. Summary of global impact performance of 1 tonne cocoa pod production

Impact Category	Unit	Cocoa Monoculture	Cocoa-Coconut Agroforestry	Cocoa-Rubber Agroforestry
Global Warming	kg CO_2-eq	7.06E+01	*3.67E+01	**7.65E+01
Acidification	kg SO_2-eq	8.11E-02	*4.31E-02	**8.54E-02
Eutrophication	kg PO_4-eq	3.65E-05	*2.25E-05	**4.15-05

Note:

* Average value for 2 plots of cocoa – coconut agroforestry (plot -2 and plot-3)

** Average value for 2 plots of cocoa – coconut agroforestry (plot-4 and plot-5)

Although the application of fertilizer and agrochemicals in cocoa farms can increase the yield, an excessive application will bring consequences to the environment, which is often neglected by farm holders or farmers. Anticipating this practice, introducing agroforestry where cocoa tree intercropped with other crops such as coconut could be seen as alternative way to mitigate environmental consequences. This study has illustrated the benefits of cocoa-coconut agroforestry system in term of environmental burden reduction. The system has performed the least contribution to global impact category under this study (Table 4.1.).

As benefit of cocoa agroforestry is in addition to cocoa shading, timber, co-products (fruits and virgin cocoa sap) and reduced agrochemicals input, there are also forest-like ecosystems that can improve ecosystem service in the area of cocoa cultivation services, such as soil condition and land productivity improvement. The case of cocoa-coconut agroforestry might be in conformity with the above premises, which is further described in detail in Sections 4.3.2 and 4.3.3 of this chapter. Therefore, appropriate cocoa agroforestry management should be applied to optimize those ecosystem services.

4.3.2. Specified Local Impacts on Soil Quality

a. Organic Carbon and Carbon Nitrogen Ratio

The organic carbon values obtained following the wet oxidation method based on the Walkley and Black (1934) protocol in the soil samples from each plot of cocoa cultivation are presented in Figure 4.12. The results showed that organic carbon at plot-2 and plot-3 representing cocoa-coconut agroforestry have the highest content than other plots of cocoa cultivation. The greater accumulation of organic carbon contents in the top soil layer of cocoa–coconut agroforestry than the content in cocoa monoculture could be explained by increased input of plant residues (litters of cocoa, coconut and *Leucaena sp, Gliricidia*) and reduced decomposition rate of organic matters.

The increasing content of organic soil carbon at plots of cocoa-coconut agroforestry resulted in increasing carbon nitrogen (C/N) ratios. As seen in Figure 4.12., C/N ratios at plots of cocoa-coconut agroforestry have the highest than other plots. Although C/N ratio keeps on changing as a dynamic process that is controlled by moisture, temperature, aeration, quantity and diversity of organic matter, decomposition rate, microbial density and diversity, the higher C/N ratio at plots of cocoa-coconut agroforestry suggests that decomposition process of crop litters at these plots run slower than of decomposition at plots of other cultivation systems.

A part of leaves shedding in dry season for cocoa cultivation, the increased quantity of organic carbon in the soil, for instance that occur at cocoa-coconut agroforestry will bring other beneficial effects, such as effects on soil aggregate stability and structure. Soils with a higher organic carbon content generally have a higher aggregate stability (Stengel et al., 1984) that reduces slaking and crusting, with direct implications for water infiltration and erosion. Higher organic presence can reduce the vulnerability of soil to erosion. In the contrary, loses in soil carbon not only result in higher atmospheric CO_2 concentrations through accelerated soil carbon oxidation, but also in a general loss of soil functioning and soil biodiversity. Another consequence of soil carbon loss is the loss of soil nutrients. These include nutrient elements within the SOM, as well as inorganic nutrients such as phosphorus and potassium that bind to mineral surfaces.

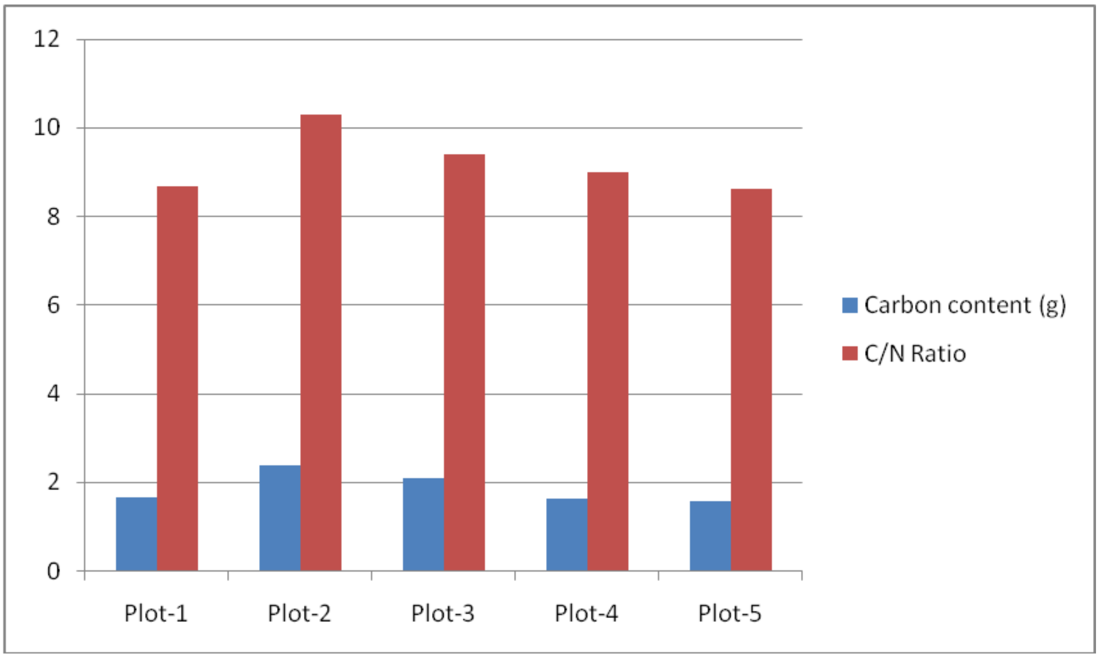


Figure 4.12. Organic carbon content and C/N ratio at each plot of cocoa cultivation

Less content of organic carbon occurred at the plots of cocoa cultivation of this study, particularly plot-4 and plot-5 of cocoa-rubber agroforestry. It has been suggested that litters derived from rubber trees might not be high as expected that has less contribution to raise organic carbon content in the soil at plots of cocoa-rubber agroforestry. Plots of cocoa-rubber agroforestry with litter narrow C/N ratio become favorable to microbes. Crop litters are easily decomposed, and can prime the rapid growth of general microbes. During later decomposition process when microbes reach higher density, the decomposers can find other nitrogen sources from the environment (e.g., or may synergistically interact with N-fixing bacteria). To maintain a good practice for soil development in the plot, it is advised to add organic matter to the plots having low C/N ratios.

As the C/N ratio can also be a predictor of nitrogen mineralization and decomposition rates in the perspective of agricultural systems, there are two competing needs for nitrogen. First, it is for the need for soil microbes to feed. Second is the need for crops, for example for nitrogen fixation in perennial (Cocoa) - legume (*Leucaena sp* and *Gliricidia sepium*) and other tree crops as refer to cultivation system under this study. The increasing of nitrogen availability in the soil at plots of cocoa cultivation will reduce competition for Nitrogen during the process of crop litters decomposition, which means decomposition will proceed as determined by soil temperature without depriving the crop of the nitrogen needs at any particular stage of growth. By the time the C/N ratio reaches equilibrium, decomposition rate of crop litters is then determined by soil temperature and nature of the plant residues and hence, nitrogen availability to the crop. This latter nitrogen becomes largely available from the decomposed organic matter. Thus, high C/N ratio may influence the rate of organic matter decomposition. Given this fact, high C/N ratio is good for organic matter decomposition in the soil through enhancement of microbial activity. The rate of the process will eventually depend on the nature of the residues, soil temperature and soil water.

b. Soil Organic Matter

Soil organic matter (SOM) is an indicator of soil quality. At the framework of life cycle assessment, land use impacts on life support function (LSF) can be represented by soil quality. Although not all aspects of soil quality can be represented by SOM, many researchers suggested SOM can be a relevant indicator for land use impact on LSF (Reeves, 1997; Stenberg, 1998; Nortcliff, 2002; Milà i Canals et al., 2007). Result analysis of soil samples at each plots of cocoa cultivation present slightly variability value of SOM, by which plot-2 and plot-3 of cocoa-coconut agroforestry possess higher SOM values than other plots of cocoa cultivation (Figure 4.13). The higher SOM content at plots of cocoa-coconut agroforestry could be predicted as these plots have higher organic carbon then other plots. This is because the main element present in SOM is organic carbon, constituting about 48-60% of the total weight of SOM.

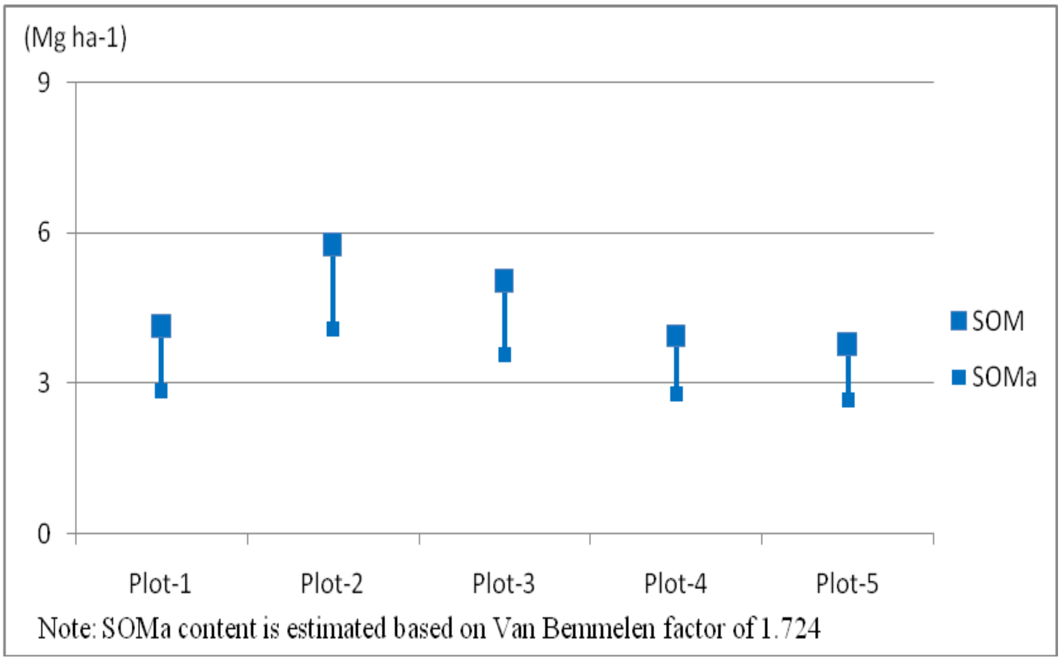


Figure 4.13. SOM content at each plot of cocoa cultivation

c. Soil Microbes

Soil function is correlated with the organisms that exist within the soil. Soil organic carbon plays role in the process of decomposition indicated by rapid the growth of general soil microbes. As soil organic carbon is the main source of energy for soil microorganisms, poor organic carbon in soil brings direct effect on reduced microbial biomass, activity, and nutrient mineralization due to a shortage of energy sources. The result of laboratory analysis for soil microbes (Table 4.2) shows that bacteria and fungi colonies could be identified at all plots of cocoa cultivation under this study. The highest number of colonies of the two identified microbe groups (bacteria and fungi) exists at plot-1 of cocoa monoculture and plot-3 and plot-4 of cocoa-coconut agroforestry. Meanwhile, plot-4 and plot-5 of cocoa-rubber agroforestry has the least colony number of soil microbes.

Table 4.2. Soil microbes at each plot of cocoa cultivation

Soil microbes	Mono	Cocoa-Coconut		Cocoa-Rubber		Unit
	Plot-1	Plot-2	Plot-3	Plot-4	Plot-5	
Bacteria:						
Pseudomonas fluoresces	4.60 $\times10^{8}$	2,25 $\times10^{7}$	3,85 $\times10^{8}$	4.65×10^{5}	5.40×10^{5}	cfu
Fungi:						
Trichoderma sp.	4.20×10^{6}	1.18 $\times10^{7}$	6.10×10^{5}	1.00×10^{4}	2.55×10^{5}	cfu

Different soil-borne bacteria and fungi are able to colonize plant roots and may have beneficial effects on the plant. The existence of *Pseudomonas sp* supports the nitrogen cycle, particularly the denitrification process that returns an amount of nitrogen to the atmosphere. Classified as autotrophs, *Pseudomonas sp* has been shown to attach to the root and efficiently colonize root surfaces. *Trichoderma* is the most prevalent culturable fungi. Some *Trichoderma* strains can interact directly with roots, increasing plant growth potential, resistance to disease and tolerance to abiotic stresses. *Trichoderma* spp. can stimulate plant growth by suppressing plant diseases (Van Wees et al., 2008). Further studies demonstrated that *Trichoderma* also increases root development and crop yield, the proliferation of secondary roots, and seedling fresh weight and foliar area (Harman et al., 2004).

d. Summary of the findings for cocoa production performance on local impacts

It is noticeable that cocoa-coconut agroforestry has the highest organic carbon content in the top soil layer than do other systems of cocoa-monoculture and cocoa-rubber agroforestry (Table 4.3). Soils with higher organic carbon content generally have a higher aggregate stability so that improves the soil quality indicated by having the higher SOM as well as to enhance land productivity measured in term of cocoa yield production.

Table 4.3. Summary of local impact performance of 1 tonne cocoa pod production

Impact Category	Unit	Cocoa Monoculture	Cocoa-Coconut Agroforestry	Cocoa-Rubber Agroforestry
Carbon Content	g	1.65	2.22	1.58
SOM	Mg ha^{-1}	4.16	5.42	3.87

Note:

* Average value for 2 plots of cocoa – coconut agroforestry (plot -2 and plot-3)

** Average value for 2 plots of cocoa – coconut agroforestry (plot-4 and plot-5)

Findings of this study might also support the fact that carbon content and carbon nitrogen ratio enable the activity of useful microbeds in the soil of cocoa cultivation, particularly in plots of cocoa-coconut agroforestry, which has the highest value of organic carbon. Such finding is in conformity with a report that cocoa – coconut intercrop increases activity of useful microbeds such as phosphate solubilizers and nitrogen fixers in soils and the organic carbon content. Given this condition, soil organisms will play key role in maintaining healthy soil in plots under this study. They improve soil-structure because they help soil to aggregate. In addition, some help to reduce plant diseases while others establish the mycorrhizal fungi that allow plant roots to access nutrients far below the reach of their roots.

4.3.3. Economic Productivity of Cocoa Cultivation

a. Land Equity Ratio

Land equity ratio (LER), a measure to evaluate the yield advantage obtained by cultivating two or more crops as an intercrop (or sequential agroforestry) plantation, and then compared to planting a single crop as monoculture plantation, was used in this study. The single crop intended in this study was referred to cocoa monoculture cultivation (plot-1), with its respective yield. Reference data of coconut sap yield obtained from coconut monoculture cultivation and raw latex yield from rubber monoculture cultivation was also retrieved for analysis. Each yield value from monoculture is used as denominator to yield gained from each plot of cocoa-coconut agroforestry and cocoa-rubber agroforestry to calculate partial LER. The value of partial LERs are then summed to give total LER for each plot of cocoa agroforestry model (cocoa-coconut and cocoa-rubber agroforestry), as presented in Figure 4.14.

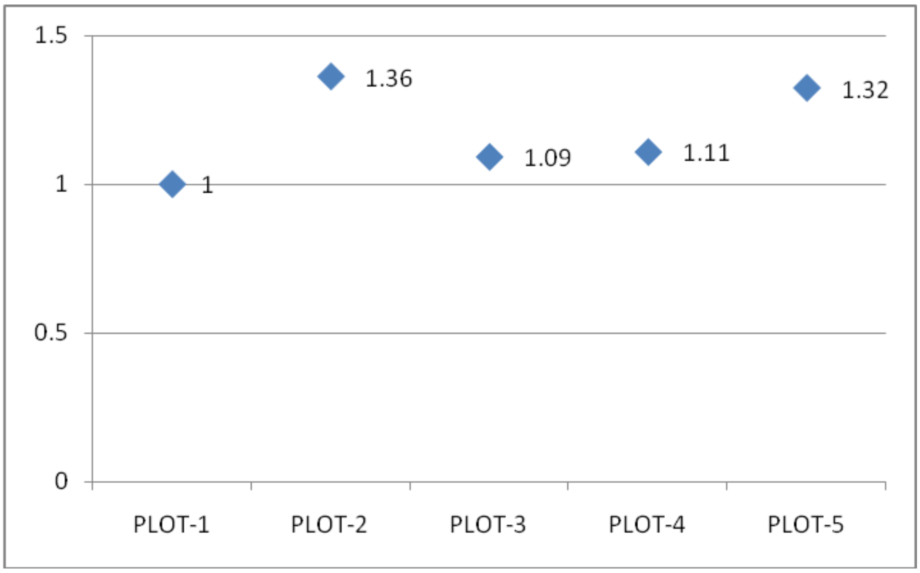


Figure 4.14. LER at each plot of cocoa cultivation

With respect to the evaluation method for land productivity by which estimates the yield advantage gained from cocoa agroforestry, the total LER for all the plots under this study was greater than one, varying between 1.09 and 1.36 (Fig. 4.14), indicating that the cocoa agroforestry system was superior to the sole cropping systems, referring to cocoa monoculture. Plot-2 of cocoa-coconut agroforestry has the highest value of LER, 1.36, which indicates that the area cultivated for monocultures (either cocoa or coconut or rubber) would need to be 36% greater than the area cultivated for cocoa coconut agroforestry for the two monocultures to produce the same combined yields. A total LER higher than 1 also illustrates the presence of positive interferences among the varieties or crops components (cocoa, coconut and shading trees) in the system of cocoa agroforestry.

b. Yield Variability of Cocoa Agroforestry Systems

Managing complex interactions between cultivated crops (crop diversity) in agroforestry system plays an important role of reducing the need for external inputs, and moves toward sustainability. Increasing crop diversity sometimes allows better resources use efficiency in cocoa agroforestry system, because with higher diversity, there is greater microhabitat differentiation, allowing the components species and varieties of the system to grow in an environment ideally suited to its unique requirements (environmental services). An important issue is whether the yield advantage from cocoa agroforestry system is affected by the enabling environment service that the system creates. Given that sense, understanding the correlation of enabling environmental service that supports an yield increase will be inevitably so that this will provide an insight to farmers (the company) how to manage their farm to increase crop yield.

As illustrated in Figure 4.15, the land productivity of cocoa agroforestry (LER) might not be directly driven by soil carbon and soil organic matter, as there is an indication of yield increasing at the same time the carbon content and SOM decrease (plot-4 and plot-5). However, some research findings suggested that increased organic content and SOM may help to reduce yield variability (Ngoze et al., 2008; Pan et al., 2009).

With respect to field conditions in plot-4 and plot-5, the increased yields might be affected by increasing agrochemical utilization during crop maintenance. It is generally known that the need for increasing agricultural productivity and quality has led to an excessive use of chemical fertilizers, although this might create serious environmental pollution.

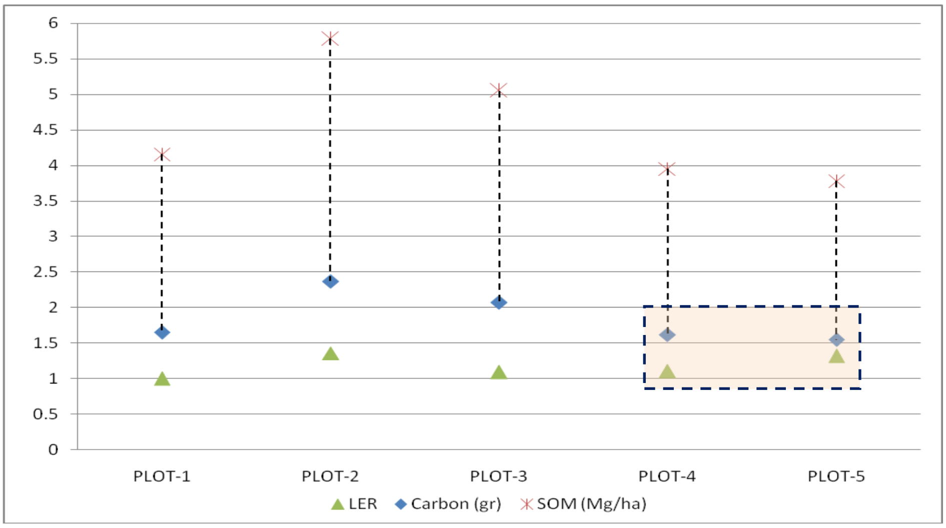


Figure 4.15. Land productivity related to carbon content and SOM at each plot of cocoa cultivation

Such indication actually has been confirmed based on the previous discussion that the plots of cocoa rubber agroforestry have higher environmental burdens of potential global impacts on climate change, acidification and eutrophication (Figure 4.9-4.11) than do other plots. These higher potential global impacts are affected due to higher inputs of fertilizer and agrochemicals to the cocoa-rubber agroforestry boundary. However, such premise still requires further investigation, evidences that can be gathered through intensive field research at the area of study to support the aforementioned indication. To get more reliable field evidence in this research, additional site samples (plots) are required in order to be representative so that approach of statistical estimates can be performed to test relation between land productivity and organic carbon stock.

Although the two-way interaction is not always apparent, a gain in soil organics in the cultivation area becomes an important indication that the agricultural system is improving and becoming more sustainable. Bruce et al. (1995) argued because of the multitude of possible soil chemical, biological and physical constraints to realizing the yield potential, improving SOC contents is an important insurance against crop failure from a soil perspective and may be the best strategy to restore fertility on degraded land, for example when the soil's water holding capacity is the major yield constraint.

4.3.4. Possible Improvements of Environmental Performance for Cocoa Production

Fertilization principally aims at providing nutrients when the soil which is not sufficient to maintain general health for trees. When cocoa trees are grown on poor soils with low nutrient levels, fertilization becomes a practical way in increasing cocoa yield productivity. The results will be optimized when appropriate fertilization is applied, considering fertilizers' type, dosage, and precised timing and operation method. If not, fertilization can affect environmental condition in the cocoa farm. The application of fertilization shall follow the recommendation based on testing result of tree's health, leaf and soil quality.

The fact that the existence of rubber trees intercropped within cocoa trees has enhanced environmental burden cocoa-agroforestry becomes important issues that need improvement in order to achieve sustainability principles. Possible improvements to settle these issues can be through selection of crops, tree spacing and spatial arrangement.

a. Selection of Crops

Crops are generally selected for high yield, but this might not be suitable for cocoa crops where shade combined with moderate yields is the important criteria. Since the motive of intercropping (agroforestry) to diversify the types of trees for cocoa shading, minimize environmental impacts and increase environmental service, the practice of cocoa-rubber intercrop should be reconsidered. As not all crops can be suitable for cocoa agroforestry, it is necessary to understand the growth characteristics of crops under different environmental conditions. The company can investigate other crops as option of intercropping with cocoa to gain better benefits.

The selection of crop species should be based on plant responses to biotic and abiotic factors. Besides the genetic factors of the plants, another biotic factor that must be considered is allelopathic potency as a biological phenomenon by which a plant (an organism) produces one or more biochemicals that influence the growth, survival, and production of other plants (organisms). Selecting crops with long-lived leaves as it have low nutrient uptake rates. Abiotic factors include the adaptation capacity of selected plant to local environment condition such as soil type, topography.

b. Spacing and spatial arrangements

Increasing the space between rubber and cocoa rows enhances the availability of light while it also helps to keep the root densities of rubber low. Rubber trees planted in east/west directed rows also have shown to provide more light into the inter row space for longer period of the day and have shown its advantages (Pathiratna and Perera, 2002). Therefore, wider inter-row spacing combined with east/ west directed rows where ever possible, can be considered as a suitable arrangement.

c. Agronomic practices

Applying fertilizers to cocoa-rubber agroforestry at the time leaf senescence sets in and rubber root activity is the least may be suitable to avoid fertilization loss. Harvesting can also reduce the density of rubber fine roots under severe pruning regimes. Therefore if the harvested part is vegetative, regeneration of new shoots can be affected due to defoliation.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The cocoa industry will continue to expand and play an important role in the economy of Indonesia. Cocoa cultivation systems will also continue to be intensified due to the stimulus of economic returns. Decrease of land productivity, pest and disease outbreak caused by intensified cocoa cultivation practices will consequently become the main constraint to sustainable development of the sector. Cocoa production system which is both economically profitable and environmentally sustainable is highly desired.

This thesis introduces the first approach for a comprehensive framework of environmental evaluation and sustainability enhancement in the cocoa plantation industry in Indonesia. The quantifiable benefits include direct evaluation of cocoa monoculture and cocoa agroforestry systems to advise regulation and environmental impact mitigation measures for policy makers, to guide cocoa farmers toward implementing good agricultural practices, and to inform consumers in their awareness and choice for more sustainable consumption of cocoa related products.

LCA is an appropriate strategic environmental tool and will become a mainstream tool to evaluate global and local environmental impacts for agricultural production systems. As a systematic approach, LCA can evaluate sustainability of agricultural practice at farm level quantitatively from a cradle-to-fate perspective. By assessing system performance, it presents a useful basis for system improvement in terms of environmental sustainability. As the existing LCA methods are not capable of quantifying local ecological impacts, which limits its ability and future application, an adaptation has been made in this thesis by using soil organic matter as a proxy indicator for sub-impact category of life support function. In addition, soil microbes and land productivity are utilized as supporting indicators.

This study aimed at evaluating the environmental performance of 1 tonne cocoa pod production from three systems of cocoa cultivation, namely cocoa monoculture, cocoa-coconut agroforestry and cocoa-rubber agroforestry. The results of the study showed that cocoa-coconut agroforestry system performed the best environmental performance than other systems in all categories of environmental impact analyzed under this study. On the contrary, cocoa-rubber agroforestry has relatively the same values as the cocoa monoculture and even higher value in some categories of environmental impact.

Cocoa-coconut agroforestry had the least impact of the three identified global impact categories of global warming, acidification and eutrophication, accounting for 3.67E+01 kg CO_2-eq, 4.31-02kg SO_2-eq, and 2.25E-05 kg PO_4 -eq consecutively. Respecting on local impact categories, cocoa-coconut agroforestry also had the highest content of organic carbon, C/N ratio and soil organic matter, of which these conditions might stimuli growth and activity of beneficial microbeds in soil at cocoa farm. This has been confirmed by the highest colony of two soil microbe groups (bacteria and fungi) that exist at cocoa-coconut agroforestry. The land productivity ratio (LER) of all cocoa-agroforestry plots were over than 1, by which cocoa-coconut agroforestry performed the highest value at 1.36, indicating that highest yield advantages gained from the cocoa-coconut system as compared to other systems.

5.2. Recommendations

Consideration of the aforementioned environmental impact levels has led me to propose that intercropping cocoa with coconut crops in cocoa agroforestry system can be a measure to promote sustainable cocoa farming practice as this illustrates benefits in terms of fewest contributions to environmental burdens, and increased soil quality improvement as compared to monoculture systems. Cocoa-rubber intercrop might not be considered as alternative to minimize potential environmental impacts at cocoa plantation.

An important issue is whether the yield advantage from the cocoa agroforestry system is affected by environmental services that the system creates for itself. Understanding correlation between yield variability and enabling environment that cocoa agroforestry create will be important, that can be investigated by further study in the future.

In order to optimize environmental service benefits from agroforestry, the cocoa industry must apply appropriate cocoa agroforestry management, including prudent crop selection prior to intercropping with cocoa trees. The case of rubber tree selection might become good instance. Improvements suggested for cocoa agricultural practice include changes in fertilization, pest protection and farm management with respect to surrounding environmental conditions such as climate and soil quality. Of course, any change in the cocoa management system affects overall performance and may make different systems show better sustainability performance.

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APPENDICES

Appendix A : Precipitation Data of the Latest 10-Year Period (2001-2013)

Month / Year	2001	2002	2003	2004	2005	2006	2007
January	308	231	346	277	195	126	208
February	133	274	177	220	283	186	157
March	202	105	145	258	211	225	317
April	88	68	53	89	100	134	176
May	79	58	199	112	5	68	156
June	239	18	31	5	81	124	102
July	44	0	32	51	86	12	109
August	0	0	2	22	167	30	126
September	16	4	21	55	32	0	0
October	232	0	249	5	141	9	48
November	192	87	240	84	118	34	102
December	65	278	166	310	328	209	345
Total	1598	1123	1661	1488	1747	1157	1846

Month / Year	2008	2009	2010	2011	2012	2013
January	122	247	260	237	344	427
February	238	293	172	87	234	243
March	374	202	105	169	232	229
April	108	190	94	273	22	290
May	134	98	304	209	89	309
June	9	10	146	150	3	204
July	9	46	142	57	106	216
August	27	31	129	26	0	39
September	0	31	346	19	0	7
October	0	10	336	33	27	42
November	362	20	171	354	79	310
December	245	123	151	306	416	399
Total	1628	1301	2356	1920	1552	2715

Appendix B : Rain Days Data for the Latest 10-Year Period (2001-2013)

Month/year	2001	2002	2003	2004	2005	2006	2007
January	14	14	14	16	13	15	6
February	7	14	11	13	16	14	13
March	14	8	9	14	9	16	13
April	9	5	8	10	10	9	11
May	3	4	13	9	1	7	8
June	14	2	3	1	7	6	7
July	4	0	3	5	7	2	4
August	0	0	1	3	6	2	7
September	2	1	5	4	2	0	0
October	11	0	6	1	6	1	2
November	9	5	12	9	7	2	7
December	5	16	7	15	23	16	14
Total	92	69	92	100	107	90	92

Month/year	2008	2009	2010	2011	2012	2013
January	7	11	18	13	17	21
February	12	14	12	5	10	13
March	19	9	9	13	11	11
April	5	7	14	14	4	9
May	10	7	18	12	11	12
June	1	2	13	7	1	11
July	2	3	12	4	6	15
August	3	3	16	2	0	2
September	0	4	18	1	0	2
October	0	3	15	2	3	1
November	16	3	13	16	7	15
December	8	9	14	19	20	17
Total	83	75	172	108	90	129

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(1) Sample of daily precipitation data in January for 1960 -1962

Daily Precipitation Data on January for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	2.9852	0	0	0.6051	0	0	0.0336	0	0	0	0	0	0	0
1960	2	10.4833	7.5312	4.0431	9.3295	4.5088	2.1001	7.1449	4.8733	3.8037	6.3011	6.8499	4.7185	6.5528	8.6837
1960	3	4.8575	3.8682	2.2824	5.4241	1.9765	1.0601	2.2175	0.7527	0.6686	0.871	1.2009	1.7317	1.0161	1.0389
1960	4	11.9269	9.8627	6.2303	14.2969	6.7578	3.7636	10.8303	7.9321	6.6029	10.2527	12.1343	8.3338	11.6687	15.6225
1960	5	0.1429	0	0	0.0262	0	0	0.0013	0	0	0	0	0	0	0
1960	6	11.3023	9.5772	7.2925	10.5641	6.9646	6.2667	7.912	5.5009	6.1803	4.5414	6.0591	7.3049	5.9114	5.7042
1960	7	2.2465	2.1985	1.431	3.2411	1.8848	1.0113	3.3301	2.8052	2.2339	3.5958	3.9997	2.3674	3.834	5.1883
1960	8	6.8776	2.5785	1.3949	3.9134	1.9146	0.8481	3.3516	2.5029	1.8492	3.3922	3.3337	2.0003	3.0985	4.2107
1960	9	1.972	1.0882	0.6781	1.5268	0.5243	0.3249	0.5552	0.1847	0.1936	0.2122	0.3369	0.5398	0.2943	0.3009
1960	10	3.6439	2.0955	1.5308	3.0757	1.5151	1.5699	1.668	1.0237	1.6076	0.8343	1.6077	1.6757	1.4573	1.3057
1960	11	2.2328	0	0	0.2237	0	0	0.0216	0	0	0	0	0	0	0
1960	12	1.2112	0.2101	0.1277	0.4697	0.1058	0.0603	0.1269	0.0384	0.0359	0.0451	0.0652	0.0979	0.0534	0.0562
1960	13	1.252	1.0852	0.6103	1.384	0.6953	0.2999	0.9253	0.454	0.3012	0.4892	0.5113	0.5434	0.4854	0.4577
1960	14	1.0865	0.904	0.6773	1.2096	0.6075	0.6647	0.6241	0.3649	0.613	0.303	0.5621	0.7377	0.5704	0.4813
1960	15	1.4958	1.5617	0.9067	1.6208	1.817	0.7594	1.7676	1.2739	0.7247	0.957	0.6937	0.7036	0.6924	0.5452
1960	16	7.5481	7.9206	6.7609	8.8421	9.6379	7.3911	9.8376	9.4665	7.1951	8.0373	7.558	7.7378	7.7459	8.2063
1960	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	18	8.649	6.5702	3.5538	8.0345	3.7524	1.7855	5.887	3.839	2.9232	4.9798	5.3171	3.9721	4.9774	6.5957
1960	19	14.85	9.627	7.12	10.9377	5.7288	5.5552	6.4661	3.3876	5.0636	2.7623	4.6996	6.8672	4.5061	3.9123
1960	20	0.5534	0.2841	0.2149	0.4204	0.1941	0.2155	0.2243	0.1381	0.2172	0.1129	0.2087	0.2364	0.2012	0.1801
1960	21	7.2792	8.4801	8.169	9.5708	11.7172	9.7768	14.2765	15.2145	10.4787	13.1021	11.7027	10.0768	11.4284	13.3558
1960	22	2.9522	2.0329	1.3976	2.2439	1.8651	1.1605	2.0359	1.4246	1.1118	1.0009	1.0032	1.2322	1.0803	0.8747
1960	23	4.7375	3.5678	2.0658	3.8443	4.2231	1.751	4.1619	2.9912	1.6508	2.2583	1.5869	1.6116	1.5844	1.2408
1960	24	1.5609	0.9685	0.4244	1.0542	0.6483	0.1712	0.9441	0.4964	0.2646	0.5402	0.4416	0.38	0.4522	0.3963
1960	25	2.3052	0	0	0.4198	0	0	0.0248	0	0	0	0	0	0	0
1960	26	17.7271	6.0891	2.6627	7.9842	2.7333	0.9708	3.0665	1.0468	0.704	1.2416	1.2564	1.7114	1.103	1.0861
1960	27	16.9465	23.3087	21.9009	31.6634	35.5588	31.0907	42.5864	45.4904	34.7097	38.9274	40.0599	29.8471	37.3097	43.1943
1960	28	3.6011	1.4678	0.726	1.7983	0.7648	0.2912	0.9928	0.4206	0.2653	0.4694	0.4555	0.5373	0.425	0.4039
1960	29	5.181	1.3857	0.8481	2.1946	1.0178	0.5286	1.9519	1.5189	1.1395	1.9764	2.0281	1.3573	1.9709	2.6098
1960	30	4.3996	4.8931	4.4618	6.6229	7.5749	6.1419	7.9589	8.3824	6.2738	7.4673	6.9602	5.9418	6.7853	7.4635
1960	31	2.5161	1.7294	1.0831	1.8442	1.7546	0.8406	1.8233	1.3295	0.7906	0.9134	0.664	0.809	0.7931	0.5472
1961	1	11.5252	7.5956	4.2984	10.6267	7.4992	2.717	9.6647	7.0004	3.047	7.6778	6.7967	4.4431	5.7888	10.0493
1961	2	15.8463	10.8967	5.3739	11.0307	6.9931	2.3668	11.1532	6.9005	2.7783	8.8773	6.5843	4.2644	5.1685	9.1764
1961	3	24.6134	17.2228	13.9198	8.1092	13.8369	13.0469	11.1891	10.1615	8.0996	9.4829	6.101	11.3758	6.4406	5.7248
1961	4	19.2185	26.3205	26.5883	15.5021	33.6417	40.1573	23.9874	28.2115	25.4216	20.8048	16.9437	30.4962	19.606	17.445
1961	5	18.4232	8.3703	4.7659	9.4162	7.5932	2.1696	7.4446	5.0664	2.0196	5.1333	3.8684	2.7559	2.8475	4.7156
1961	6	6.9976	6.4735	4.9365	4.8077	5.9161	4.7872	6.9232	5.9646	3.8674	6.5081	5.336	5.2574	4.5965	6.4361
1961	7	24.4403	24.0538	21.0674	19.8161	27.9507	25.7321	22.4615	23.6247	18.1243	17.7392	14.8692	22.5475	15.2597	14.2287
1961	8	2.6263	0.9805	0.4179	1.728	1.1623	0.203	1.2899	0.8307	0.2398	0.7244	0.4885	0.1421	0.1554	0.3516
1961	9	8.8326	4.459	2.8216	1.8841	2.6431	1.0977	3.427	1.9229	0.7147	3.2484	1.6545	1.201	0.5716	1.1934
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	1.082	2.1083	2.1767	1.3989	2.6417	2.9564	2.0658	2.4561	2.0715	1.8087	1.5686	2.5953	1.7044	1.4638
1961	12	41.1829	16.1265	7.6766	17.5756	13.1922	2.4893	12.5284	6.8954	1.905	6.7987	3.2286	2.2938	1.4717	2.1621
1961	13	11.4973	6.3592	4.6163	5.6501	6.1935	4.0914	5.0923	4.2508	2.7192	3.3669	2.2425	3.3702	1.9558	1.8355
1961	14	3.1123	5.4831	5.5941	4.222	6.4556	6.5285	6.0937	6.8925	6.5862	6.2871	6.4277	7.3929	7.5672	7.485
1961	15	10.81	9.8536	7.17	10.7132	8.5703	4.9835	13.234	11.1223	11.6655	12.4388	11.5233	8.168	13.6491	10.9219
1961	16	24.783	13.7356	5.0559	25.1108	12.6235	2.4976	19.2266	11.3651	3.2114	10.6262	6.4311	2.8034	2.9126	5.4524
1961	17	3.9936	3.3735	3.5512	4.0224	4.2796	3.0269	5.1896	5.7844	7.8294	5.8972	6.9983	5.1759	9.4409	7.0617
1961	18	28.9072	24.9605	23.6566	13.2559	26.1805	29.7389	19.1443	20.705	18.0659	16.0217	11.5551	23.7574	12.8253	10.4017
1961	19	15.3737	23.7591	25.6218	17.5754	32.1231	37.3625	25.2671	29.6996	27.2808	22.2232	19.3419	31.4083	22.285	18.2929
1961	20	15.2495	14.8367	12.1484	16.5604	17.3346	14.2501	17.4701	16.5259	12.1251	13.7744	11.7853	13.8829	11.4208	11.4361
1961	21	1.9224	2.6437	0.8027	5.1167	2.0729	0.5846	5.2884	3.1096	0.8949	3.4123	1.8868	0.6769	0.5986	1.2816
1961	22	1.7696	0.8763	0.5132	0.3015	0.3985	0.1388	0.3977	0.1582	0.0553	0.3464	0.0937	0.1766	0.0659	0.0623
1961	23	0.0705	0.044	0.0287	0.0863	0.0854	0.0307	0.1472	0.1299	0.058	0.1414	0.1009	0.0342	0.0448	0.0805
1961	24	12.0791	14.1014	14.6116	12.0555	20.1742	22.9243	14.6732	16.9247	14.3771	11.2668	9.1336	17.2427	9.7973	8.0222
1961	25	5.0382	7.0774	5.8489	8.2864	8.7446	8.6724	9.4408	8.7497	6.053	6.8444	4.9757	6.9522	4.1586	4.0657
1961	26	2.4658	5.0112	5.7398	3.3486	7.3386	9.4175	5.336	6.6275	5.9397	4.5483	3.7637	7.272	4.1733	3.3906
1961	27	12.0385	22.6221	23.4028	17.8601	30.6954	38.8983	25.1588	28.296	24.2982	20.5311	15.7191	29.5557	16.2871	13.5495
1961	28	4.1379	7.4332	6.0602	7.948	8.2133	8.0438	9.6203	8.7566	5.8908	7.4408	5.4332	7.2568	4.6967	4.6276
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	25.6419	11.2002	7.3558	16.4908	13.9622	4.9964	12.9121	10.9727	9.0394	8.9106	8.8244	6.0808	9.7456	8.1375
1962	2	17.5202	34.7799	33.3244	27.6919	43.9358	52.1632	37.9072	39.8321	33.5342	29.53	22.2206	38.3269	21.9056	18.6652
1962	3	6.2811	10.6241	12.5618	9.3709	15.1223	14.0806	14.7593	17.4704	20.2786	15.3793	16.5574	16.2099	21.696	16.3172
1962	4	0.9409	1.7518	2.2208	1.7793	2.5154	2.0207	2.7353	3.2979	4.2781	3.1488	3.7049	3.0602	5.0678	3.7215
1962	5	18.2387	6.913	2.993	10.8407	7.8212	1.5332	8.2669	5.3854	1.7542	4.5666	2.9987	1.0671	1.0607	2.0882
1962	6	29.8286	25.3253	22.5517	23.5105	32.8136	30.5719	25.8319	26.0843	20.1201	18.4079	14.2481	22.5194	13.2915	11.8698
1962	7	5.6084	3.2107	2.6082	4.6316	4.4248	2.1652	6.1581	5.0454	4.1742	5.4894	5.0158	2.8433	4.6202	4.1476
1962	8	22.8743	24.9254	21.7224	25.3643	33.0605	31.2517	29.4737	29.2022	21.4903	22.5832	18.5022	24.4471	17.7021	19.3169
1962	9	9.2702	17.9522	18.6809	19.0761	24.3748	21.7706	27.4202	29.6336	30.8245	27.6579	28.6276	25.8901	34.8603	29.7811
1962	10	15.5418	8.2751	6.0749	9.9004	10.3153	6.6738	8.1226	7.2061	4.634	4.8335	3.7125	4.9796	3.1573	3.0393
1962	11	9.6352	14.3266	13.1325	12.205	17.5131	18.9343	17.4972	16.996	12.7741	14.1822	10.3503	14.7003	8.6386	8.5337
1962	12	3.8425	1.4154	0.6508	2.2756	1.6444	0.3156	1.5403	1.0424	0.3546	0.7619	0.5248	0.214	0.2268	0.3774
1962	13	24.1304	27.2089	23.5334	28.3785	32.7081	28.5435	33.1211	31.5547	25.0046	26.5263	22.4308	26.1754	22.3477	21.2437
1962	14	13.0512	6.5944	2.6254	10.9415	6.7573	1.5145	8.9984	5.7969	1.9194	5.2002	3.1814	1.2695	1.1959	2.1882
1962	15	19.0723	23.6217	23.3349	20.8235	30.5206	30.2235	27.6035	28.949	24.481	23.8203	20.8191	26.9194	21.7237	20.4392
1962	16	27.9516	27.8899	25.2615	29.4209	38.1152	35.0027	34.5563	34.6932	27.0797	27.009	22.5012	28.357	22.0663	21.0773
1962	17	11.1927	14.1772	14.3588	12.9661	18.32	17.51	16.7987	17.9769	16.197	15.127	14.1738	17.1436	15.9858	14.6031
1962	18	28.3387	29.4354	29.2945	25.5216	38.5702	38.0564	31.408	33.6413	28.1395	26.3061	23.3602	33.0541	25.1899	24.5654
1962	19	21.8896	31.202	31.8218	28.3958	43.5621	44.8531	40.5973	43.6787	37.5692	36.8543	33.3798	39.6994	35.6295	34.5271
1962	20	9.4238	11.9316	10.6845	12.5869	15.5737	14.9142	16.9681	16.0557	12.1989	13.9496	10.9177	12.3813	9.6616	9.1855
1962	21	17.0858	8.0328	3.2656	13.5768	8.5049	1.8648	10.9458	7.1344	2.3565	6.3056	3.865	1.5424	1.4777	2.6654
1962	22	21.7648	38.4284	42.4113	28.7878	52.3413	62.957	45.3922	51.2423	46.8761	40.772	34.4451	51.7347	36.8715	30.783
1962	23	15.0912	30.1927	35.2986	21.5234	42.4776	51.919	34.1228	41.0634	39.8251	31.282	27.927	43.6079	32.7599	25.6826
1962	24	5.2416	2.6281	1.0693	4.279	2.5818	0.6026	3.4316	2.147	0.6967	1.9373	1.1659	0.5004	0.4298	0.7986
1962	25	4.4729	7.8892	8.1084	6.0771	10.2241	12.2597	8.8304	9.5469	7.8404	7.1807	5.4225	9.5279	5.4024	4.7271
1962	26	1.6407	2.2135	2.5645	2.3699	2.9662	2.3411	3.6886	3.9986	4.6548	4.093	4.3614	3.5324	5.3899	4.2563
1962	27	2.6537	4.2827	4.8747	2.6589	5.8811	7.357	4.4394	5.2223	4.5347	3.8638	3.0591	5.6906	3.185	2.7038
1962	28	1.8332	3.1422	4.0276	3.4829	4.7634	3.9508	5.5196	6.5702	8.34	6.4863	7.4008	6.0227	9.8351	7.3749
1962	29	2.3026	4.4419	4.8341	3.1722	5.9593	7.3851	4.6813	5.3972	4.6423	3.8537	2.9951	5.7478	3.2519	2.6799
1962	30	3.8508	7.4259	7.8518	5.5919	9.8058	12.0899	8.0222	8.9849	7.6137	6.5067	4.9612	9.3607	5.2642	4.3865
1962	31	2.8588	1.8823	0.6861	3.5744	1.8598	0.4936	3.1345	1.9645	0.6331	1.856	1.0747	0.4531	0.3951	0.7224

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(2) Sample of daily precipitation data in February for 1960 -1962

Daily Precipitation Data on February for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	14.9043	9.6419	5.0278	11.428	4.6645	2.2321	6.5362	3.5108	2.6815	4.4878	4.815	4.5506	4.4194	5.5227
1960	2	3.6569	0.6286	0.378	1.2279	0.7775	0.3647	0.8339	0.6068	0.3604	0.4115	0.3318	0.3119	0.3647	0.2681
1960	3	7.3309	0.4738	0.2108	1.1279	0.3224	0.0873	0.5042	0.248	0.1316	0.2693	0.2155	0.1893	0.2203	0.1905
1960	4	10.6266	8.4706	6.4613	11.2027	10.8698	7.7093	12.1941	10.7907	8.0818	8.7142	8.6856	7.3847	8.2839	8.3816
1960	5	9.6503	1.9039	1.1929	2.6757	2.0634	1.0301	2.2367	1.5254	0.9688	1.0695	0.9097	0.9998	0.9363	0.7363
1960	6	14.1503	11.4267	9.8789	16.4507	17.1832	13.2988	21.9288	22.0584	15.2851	19.9252	17.7212	12.5382	15.6784	17.628
1960	7	7.8623	7.5064	4.9743	7.8694	7.4653	4.2256	8.0254	5.6894	4.0007	3.9675	3.5619	4.2867	3.9159	3.0288
1960	8	21.113	12.2928	12.0278	15.2286	14.7206	14.2111	18.8969	18.8674	14.7999	16.763	15.5678	15.1948	15.9039	17.6068
1960	9	13.839	5.4204	3.8797	6.9499	3.5154	3.0735	2.7793	1.413	2.307	1.3185	2.0012	3.7778	2.0536	1.592
1960	10	26.3123	21.3879	17.7507	24.4138	23.3562	18.8148	26.663	23.6741	18.5063	20.5821	19.3298	20.0473	19.0838	19.917
1960	11	4.3677	2.3919	1.6931	2.6188	2.0905	1.3475	4.8583	3.924	2.3695	3.2628	2.5488	1.3273	2.1331	2.3786
1960	12	7.564	6.0882	4.5572	8.2408	4.2798	4.6351	4.4648	2.64	4.1723	2.1953	3.7498	5.0935	3.8599	3.1376
1960	13	10.8647	6.2983	4.4473	7.5411	4.3379	3.5205	4.2818	2.5737	2.9945	2.5128	2.7963	4.2172	2.6115	2.2273
1960	14	11.9175	10.4528	7.2031	11.2097	8.3536	5.9498	9.0444	5.5417	5.444	4.1566	4.9772	6.6966	4.9633	4.0181
1960	15	6.7332	6.1226	3.9687	9.1916	5.7888	3.0552	10.5288	8.9109	7.1404	11.9115	12.7606	7.5991	12.5782	16.7803
1960	16	10.3781	3.5957	2.1729	4.3165	3.8273	1.777	3.4475	2.4297	1.5219	1.7052	1.2487	1.6787	1.5373	1.0047
1960	17	3.0218	1.6971	1.1519	1.9131	1.7181	0.9416	3.0627	2.5303	1.3859	2.268	1.4759	0.8905	1.2418	1.3044
1960	18	6.3207	5.7325	3.5767	8.7904	5.1773	2.5845	8.8594	7.2016	5.7328	9.8207	10.2589	6.574	10.1376	13.0185
1960	19	2.2321	1.2101	0.5879	1.9186	1.1246	0.2966	4.1935	2.5514	0.8028	2.78	1.5833	0.3079	0.6865	1.1967
1960	20	3.751	1.9464	1.0555	2.2683	0.8388	0.4203	1.4908	0.6749	0.3462	0.7589	0.6174	0.675	0.4148	0.5156
1960	21	14.963	11.2788	5.4706	12.6453	4.0967	1.9733	4.5829	1.3186	1.1196	1.596	1.9598	3.3307	1.6592	1.6741
1960	22	18.2304	21.7403	21.2092	24.5187	31.2987	26.8197	38.5903	40.9207	29.0782	36.0205	31.7113	27.231	31.1153	35.645
1960	23	9.4803	6.9434	3.3731	9.5706	4.9358	2.0441	9.8373	6.8228	4.6074	9.327	8.2657	4.9627	7.4401	10.0202
1960	24	28.67	22.0268	15.4793	25.4063	13.8453	12.1217	10.303	5.1655	8.9908	4.8203	7.4944	15.0035	7.841	5.8389
1960	25	17.6059	20.7019	20.2929	27.9061	32.619	29.6473	36.8594	40.8181	32.1856	36.8836	34.3859	28.554	34.4802	38.0831
1960	26	1.6564	1.1406	0.5999	1.2657	0.6503	0.2607	0.8317	0.4095	0.2697	0.4454	0.4235	0.4871	0.4285	0.3783
1960	27	2.314	1.2691	0.692	1.9013	0.8981	0.3493	1.9193	1.0634	0.4504	1.2169	0.8247	0.5324	0.5203	0.6466
1960	28	6.9158	0.6685	0.2531	1.2824	0.4327	0.1027	0.6211	0.3015	0.1585	0.3424	0.2542	0.2167	0.2558	0.216
1960	29	7.7789	5.7416	2.969	7.7665	4.3924	1.839	8.504	5.9664	4.0241	8.0334	7.0734	4.1605	6.3198	8.4556
1961	1	1.5975	2.4088	0.7025	5.1952	1.9651	0.5651	5.1377	3.0692	0.8966	3.3368	1.9311	0.6992	0.6676	1.4759
1961	2	12.7855	4.5404	2.0331	9.4811	5.8683	1.1755	5.9704	4.0219	1.2824	2.8466	2.028	0.838	0.893	1.6172
1961	3	9.497	8.3975	4.8686	15.0432	8.7233	3.7588	14.6133	11.1541	8.3473	11.6891	10.1677	6.1344	9.8389	9.9191
1961	4	19.2581	19.4255	19.4816	13.4758	24.0136	25.6951	20.3829	21.6554	18.2109	18.8543	15.1535	22.6821	16.2603	15.327
1961	5	2.9589	5.4517	5.4322	7.7714	7.2302	5.407	10.5443	10.5987	11.1526	11.0755	11.7349	8.7695	13.8892	12.3071
1961	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	7	1.7545	2.7674	0.8876	5.7797	2.3509	0.8686	5.8269	3.6681	1.2277	3.8591	2.3647	1.0138	0.8719	1.85
1961	8	3.5319	8.264	9.1377	6.0288	12.4104	15.7575	9.5037	11.365	9.7735	8.0903	6.5858	12.0357	7.495	6.6774
1961	9	8.0991	6.1187	5.4581	7.0955	8.8363	7.9708	7.0725	7.1538	5.1851	4.9972	3.9898	6.1025	3.9816	3.8566
1961	10	5.5945	9.3909	5.4036	14.8802	9.4314	6.8093	16.5516	12.0512	5.9035	11.9691	7.862	6.5519	4.8825	6.7495
1961	11	9.7429	3.2484	1.3597	6.4955	3.9573	0.6223	3.8863	2.4946	0.701	1.7084	1.1901	0.4341	0.5019	0.9376
1961	12	0.7605	1.0604	0.3196	2.2132	0.8905	0.2613	2.2874	1.3777	0.4101	1.5455	0.9003	0.3151	0.3023	0.6878
1961	13	2.0588	3.1772	0.9279	6.3993	2.4647	0.7096	6.451	3.7938	1.1126	4.1379	2.3536	0.8805	0.8175	1.7938
1961	14	8.0467	3.7987	2.3482	2.3968	2.3894	0.8358	2.2954	1.1965	0.4446	1.6898	0.6716	0.9712	0.443	0.5243
1961	15	24.7585	15.1434	11.1518	19.2959	18.472	12.8181	16.4209	14.59	9.1849	11.073	8.6724	11.2816	7.805	8.2326
1961	16	45.6171	23.4025	15.9041	24.0009	20.9121	8.4513	21.6974	17.2547	11.8901	17.1976	14.037	11.3965	13.2995	13.8676
1961	17	33.4418	24.3979	20.3641	15.4442	23.7432	22.8871	20.3174	18.4198	13.8446	17.0646	11.02	19.2655	10.7979	10.3616
1961	18	44.3116	26.5376	21.2082	25.6846	31.7815	25.0295	27.5569	24.3454	16.2541	20.7931	14.677	19.9535	12.2047	13.4213
1961	19	41.6899	29.753	25.8665	40.3135	37.4644	21.4357	45.4937	43.0212	45.9671	45.434	46.7995	34.4801	56.4655	47.9141
1961	20	12.5069	18.9575	20.6391	18.4241	28.5434	28.8201	26.6218	30.212	29.5222	25.8125	25.3707	28.7252	30.6226	26.3475
1961	21	5.5098	8.1136	7.0347	7.4424	9.6783	9.2856	10.6664	10.1985	7.0007	9.3815	7.0645	8.5958	6.0633	6.7466
1961	22	1.0527	2.0854	2.2867	1.5785	3.2558	3.8186	2.6632	3.084	2.5344	2.3943	1.9275	2.9882	1.9769	1.9049
1961	23	4.7826	9.4029	10.8007	8.9985	12.1873	11.3992	13.7135	15.9668	21.7683	16.5091	19.1201	17.2056	26.548	20.2826
1961	24	21.2129	14.6417	11.6536	18.7306	18.3038	12.1701	18.9572	17.8113	15.9849	16.2639	15.6734	14.1554	17.6612	15.8396
1961	25	1.6145	3.2177	3.3072	2.1359	4.0968	4.6882	3.3508	3.8594	3.2386	3.0237	2.5607	4.2162	2.8343	2.613
1961	26	0.1262	0.0564	0.0307	0.0515	0.0639	0.0224	0.1467	0.0943	0.03	0.1462	0.0991	0.0198	0.02	0.0819
1961	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	11.1147	16.3209	18.943	13.9185	22.5412	23.5099	20.7338	24.0025	24.8132	20.7794	19.8891	24.1072	24.4389	18.7672
1962	2	6.7811	9.3331	8.563	7.995	10.6261	11.0956	11.4672	10.8348	7.5998	10.4141	8.342	10.6519	7.6653	9.7451
1962	3	1.5182	2.7932	3.2503	1.7081	3.783	4.9054	2.6674	3.2746	2.946	2.2711	1.8128	3.8668	2.1034	1.63
1962	4	7.1764	2.5244	1.1965	3.9155	2.7545	0.5596	2.6565	1.7246	0.552	1.3279	0.8715	0.3739	0.3403	0.6134
1962	5	16.7191	17.7694	11.9491	21.7575	18.152	14.8217	22.5246	17.853	10.5531	15.2889	9.7967	12.1777	7.0361	7.4629
1962	6	3.1932	6.515	7.2671	4.4234	8.9987	11.2093	7.0037	8.2254	7.055	6.4928	5.6105	9.37	6.3183	6.4783
1962	7	4.2779	7.1081	7.6678	6.805	8.9971	8.8371	9.5324	10.2935	10.7617	9.478	9.0553	9.9623	11.1264	8.5533
1962	8	6.2297	11.6018	10.683	11.0881	14.6619	17.0171	14.7633	14.4558	11.0533	11.55	8.2256	13.0137	7.5039	6.7291
1962	9	14.8675	32.2197	35.8551	26.4561	45.2757	54.5367	39.3888	45.2616	43.5871	36.2251	31.7743	46.7288	37.7864	29.4405
1962	10	0.8042	0.5998	0.5494	0.4409	0.7887	0.7564	0.9892	0.858	0.5374	0.9485	0.6671	0.5903	0.3655	0.5257
1962	11	8.8942	17.8969	21.1606	13.04	26.3572	32.3881	21.1591	25.5963	25.3645	20.0728	17.883	27.1766	21.4783	16.3724
1962	12	8.07	3.8342	2.3065	5.1686	3.9985	1.3733	4.317	3.1818	1.4176	3.3865	3.0637	2.2493	2.7012	4.5284
1962	13	16.4559	24.6022	27.5237	16.1422	33.5729	43.099	23.8768	28.1532	25.3783	20.0514	15.8509	32.9754	18.0815	15.0368
1962	14	4.851	7.8607	8.7493	6.996	10.1966	10.2358	10.1329	11.1868	11.5238	10.294	10.0749	11.5396	12.4095	10.4026
1962	15	24.1524	17.7755	15.6104	19.3933	22.9887	19.4905	19.9641	19.278	15.4398	15.203	12.1949	16.4938	12.5358	10.4955
1962	16	16.8332	28.1214	25.5656	25.3478	33.6499	39.1996	32.7535	31.8153	24.899	25.2554	17.5415	30.3432	16.3254	14.1895
1962	17	16.2551	31.2274	36.9856	25.3352	44.7107	50.8738	39.9011	46.9785	50.3011	39.9251	37.3389	49.0018	47.2793	34.4873
1962	18	11.9396	17.3077	18.6553	11.3762	22.8019	28.5229	17.6108	20.2676	17.6405	15.2896	11.4576	21.9058	11.9042	9.7927
1962	19	1.4571	2.6621	3.0404	2.7684	3.5643	2.8522	4.3281	4.7484	5.2897	5.2768	5.838	4.8452	7.2991	7.1279
1962	20	23.131	15.2306	12.815	14.6955	18.0044	14.9209	14.2455	13.646	9.7236	10.3481	8.1382	12.4296	7.9474	8.289
1962	21	18.7558	12.5164	10.4356	12.9773	15.7252	13.3611	12.6758	11.9662	8.6543	8.7511	6.3484	10.135	5.8116	5.1382
1962	22	18.4519	13.5769	8.1551	19.3056	13.6706	6.0521	19.2684	14.644	9.7002	15.1432	12.58	8.7724	11.6034	13.1796
1962	23	18.8254	6.7651	2.9016	12.4296	8.3264	1.5659	8.3968	5.4661	1.7	3.8933	2.485	1.0207	1.0007	1.6418
1962	24	8.5147	13.1479	14.3629	10.3487	17.6226	19.5867	16.379	17.9569	17.1973	15.3587	13.3313	17.8599	15.0386	12.0186
1962	25	22.402	13.6412	9.2618	17.0135	15.8571	10.5722	14.8917	12.1476	7.3817	9.3211	6.2731	8.0996	4.8668	4.7801
1962	26	3.286	2.6978	2.9484	2.5455	3.5923	2.6807	4.7727	4.7788	5.1822	5.3064	5.1505	3.8263	5.7594	4.7968
1962	27	11.3379	22.4094	26.2122	13.8768	31.6421	40.7599	22.918	28.0387	27.043	20.5561	17.3855	32.7267	21.1022	16.5945
1962	28	10.2575	23.1104	26.7669	14.153	35.1305	48.2859	23.6108	29.922	29.117	19.7478	15.7379	33.6292	18.8668	13.6687

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(3) Sample of daily precipitation data in March for 1960 -1962

Daily Precipitation Data on March for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	4.8298	5.2326	4.8537	5.8789	6.6874	5.7465	8.6959	8.7555	6.416	7.6843	6.6646	5.9018	6.7221	7.3259
1960	2	5.8892	0.491	0.3005	1.0933	0.4384	0.2101	0.8453	0.6128	0.3593	0.6147	0.4161	0.2027	0.288	0.328
1960	3	8.7164	3.5097	3.3699	4.6364	4.3468	3.9755	4.7425	4.7541	3.9104	4.2952	3.8623	4.2343	4.1569	4.2595
1960	4	6.3663	3.6596	2.9115	5.0941	4.1581	3.4382	6.4467	5.8905	4.4305	5.004	4.7181	3.3588	4.2967	4.5873
1960	5	5.3125	4.1476	2.7926	4.6719	3.3095	2.256	4.406	3.1008	2.472	3.0478	2.5145	2.5221	2.1048	2.0139
1960	6	0.6902	0.4668	0.2979	0.5979	0.2209	0.1506	0.2495	0.0863	0.0933	0.0999	0.1536	0.2485	0.136	0.134
1960	7	4.1695	4.1115	2.4873	5.3632	3.2415	1.6685	5.6126	4.5806	3.7352	6.0354	6.3774	4.2461	6.3714	8.1592
1960	8	0.7579	0.3452	0.1185	0.4154	0.2249	0.044	0.7588	0.4023	0.1191	0.4411	0.2314	0.0404	0.094	0.1725
1960	9	6.2874	5.1086	3.6725	5.6563	3.1863	3.0293	2.9141	1.5054	2.5226	1.2719	2.1525	3.7072	2.2567	1.7538
1960	10	1.4016	0.2214	0.1325	0.481	0.113	0.0659	0.127	0.0394	0.04	0.0467	0.0679	0.1058	0.0577	0.0572
1960	11	1.8429	1.7043	1.0962	2.4871	1.5486	0.8151	3.3495	2.7099	1.9271	3.3108	3.2676	1.9037	3.0745	3.9902
1960	12	0.107	0	0	0.0175	0	0	0.0009	0	0	0	0	0	0	0
1960	13	0.1193	0.0706	0.0242	0.0825	0.0462	0.009	0.1551	0.0829	0.0245	0.0901	0.0476	0.0083	0.0195	0.0356
1960	14	0.3901	0.7395	0.3925	0.8935	0.5365	0.208	0.7332	0.4042	0.2599	0.4207	0.4007	0.3896	0.4157	0.3568
1960	15	0.3731	0.3217	0.1634	0.3498	0.2032	0.0742	0.2692	0.1402	0.0881	0.1467	0.136	0.1406	0.1403	0.1209
1960	16	6.0775	5.1887	3.0571	6.1762	3.0327	1.6672	4.612	3.2538	2.7079	4.0959	4.5106	3.6054	4.4873	5.5485
1960	17	3.6723	2.0043	1.2114	3.1018	1.4699	0.7566	2.4065	1.6844	1.2512	2.1151	2.144	1.5234	1.9607	2.4447
1960	18	1.4274	0.4807	0.2907	0.744	0.2377	0.1456	0.2683	0.0882	0.0912	0.1006	0.1539	0.2396	0.1336	0.1318
1960	19	3.1907	1.904	1.108	2.5771	1.044	0.555	1.3766	0.5944	0.4366	0.6466	0.7385	0.9287	0.6309	0.6267
1960	20	1.2097	0.6993	0.3104	1.196	0.6805	0.1504	2.5642	1.5346	0.4433	1.6962	0.9018	0.1338	0.3551	0.6482
1960	21	2.2974	1.5393	0.8173	1.7324	0.6883	0.3308	1.2512	0.583	0.2952	0.6257	0.5205	0.5355	0.3566	0.4324
1960	22	0.1722	0.0625	0.0287	0.0938	0.0512	0.0147	0.0742	0.043	0.0244	0.045	0.0382	0.0317	0.0416	0.034
1960	23	0.5693	0.4355	0.2547	0.5776	0.2422	0.1278	0.421	0.2064	0.1134	0.221	0.2033	0.2022	0.1408	0.166
1960	24	4.5832	3.3938	2.0304	4.4874	1.647	0.9974	1.828	0.6095	0.6187	0.6895	1.0609	1.667	0.9247	0.9096
1960	25	12.9243	10.0353	7.4263	11.4021	5.7603	6.021	6.7864	3.9174	5.5808	3.181	4.7912	7.6254	5.2056	4.1684
1960	26	20.4187	18.4338	12.2182	20.0713	15.5889	10.0839	15.1235	10.0395	9.0215	7.3252	7.5757	11.3554	8.7408	6.2706
1960	27	3.1121	2.3819	1.0774	2.6984	1.843	0.5087	3.4949	2.0411	0.9291	2.0978	1.5191	0.9763	1.3705	1.3094
1960	28	0.1238	0.1204	0.0561	0.141	0.0982	0.029	0.1443	0.0859	0.0483	0.087	0.0755	0.0624	0.0832	0.0678
1960	29	0.7866	0.7742	0.3369	0.8153	0.5329	0.1419	0.7483	0.42	0.2257	0.4393	0.3563	0.3105	0.3873	0.3152
1960	30	11.9354	14.4377	12.9481	19.4732	21.1502	17.9011	28.0153	29.423	21.425	24.3154	23.4676	17.5689	23.3942	25.1792
1960	31	1.9041	1.4507	0.8996	1.9271	0.6807	0.4454	0.8121	0.2814	0.2842	0.3131	0.4854	0.7607	0.4341	0.425
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	2.1941	0.8565	0.3915	1.5307	1.0126	0.204	1.0332	0.6987	0.2451	0.5801	0.4683	0.2482	0.3222	0.5368
1961	3	36.9757	23.708	16.7716	36.7619	31.0212	17.8641	33.5841	28.915	20.3285	23.6857	20.5299	18.2052	19.6857	19.3801
1961	4	34.1255	30.6462	30.4572	20.5831	34.1961	31.1128	34.0503	35.8857	36.5044	35.983	33.0347	35.6146	39.3073	33.4171
1961	5	8.6158	8.5408	5.884	11.4104	8.8955	4.9241	13.4847	11.0659	9.0123	11.3568	9.41	6.6731	9.3892	8.1663
1961	6	10.904	14.7489	15.6597	9.3966	19.3653	22.3386	15.1429	17.6468	16.934	13.943	11.9518	19.0761	14.2343	11.4757
1961	7	0.0472	0.022	0.013	0.0194	0.0263	0.0109	0.0537	0.036	0.0128	0.0529	0.0352	0.009	0.0073	0.0255
1961	8	8.8151	15.8252	13.0966	15.3738	18.5311	18.405	20.4438	19.2217	13.6977	16.0188	11.7445	15.8978	10.4061	9.6734
1961	9	0.1191	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	0.3214	0.1427	0.0746	0.1299	0.1627	0.0537	0.3673	0.2334	0.0717	0.3491	0.2211	0.0447	0.0424	0.1566
1961	12	2.4209	1.1255	0.6226	0.4174	0.5572	0.1849	0.6965	0.3411	0.1125	0.6184	0.26	0.2175	0.0985	0.1785
1961	13	0.5901	0.2617	0.1363	0.2384	0.2984	0.098	0.6775	0.4303	0.1314	0.6424	0.4068	0.0817	0.0778	0.2878
1961	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	15	17.1577	8.2626	5.7127	13.5811	10.9232	4.3766	12.1792	10.7749	10.6553	9.6532	9.9748	6.4874	12.0218	9.2397
1961	16	0.6284	1.1295	0.4586	2.0527	0.9859	0.3623	2.3386	1.5085	0.5613	1.7678	1.3	0.653	0.8584	1.5176
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	14.4897	4.756	1.8368	9.3299	5.9204	0.8449	5.8271	3.6936	0.9898	2.4923	1.628	0.5478	0.6229	1.0894
1961	19	1.2528	1.8526	0.5226	3.5972	1.4827	0.3976	3.8195	2.2387	0.6373	2.352	1.2655	0.4551	0.4166	0.82
1961	20	20.0481	7.3143	3.5063	11.176	8.245	1.6744	8.0143	5.1859	1.6061	4.0206	2.4075	1.2652	1.0174	1.5843
1961	21	6.552	4.6217	1.8908	5.1222	2.8502	0.8129	5.9138	3.2615	0.9375	3.9518	1.9041	0.958	0.669	1.2354
1961	22	0.7971	0.4761	0.1561	0.9882	0.5041	0.101	0.8892	0.5417	0.1488	0.4928	0.2823	0.0943	0.0966	0.1817
1961	23	1.564	0.9288	0.302	1.951	0.9857	0.195	1.7527	1.0637	0.2883	0.9648	0.55	0.1819	0.1868	0.3525
1961	24	6.614	2.2232	0.9614	4.5568	3.0578	0.5474	2.9858	2.0582	0.6305	1.2921	0.9008	0.3452	0.382	0.6031
1961	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	26	9.9516	3.1405	1.1982	6.73	4.1948	0.5918	4.364	2.7991	0.7223	1.8248	1.2016	0.3791	0.46	0.7901
1961	27	18.6669	9.6632	5.8053	8.3044	7.6601	2.9668	8.9882	6.597	5.5872	7.3784	5.7145	4.3122	6.4981	5.1284
1961	28	7.855	4.9121	3.4492	8.505	6.3892	2.8653	8.5615	7.6145	7.183	7.0026	7.0543	4.4448	8.3308	6.519
1961	29	11.5936	3.5993	1.3665	7.8196	4.8253	0.6733	5.0475	3.2403	0.8238	2.1018	1.3793	0.4325	0.5276	0.9068
1961	30	5.1664	5.2081	4.7817	5.114	5.6581	3.8943	7.6539	8.0676	10.3405	8.4908	9.2247	6.6555	12.5832	8.966
1961	31	0.7977	1.0684	0.8181	1.164	1.0027	0.6145	1.6791	1.5002	0.8954	2.205	2.4979	1.6121	2.5336	4.3229
1962	1	2.4795	4.7579	5.3206	3.1517	7.0592	8.784	5.261	6.2969	5.6173	4.5192	3.5773	6.5019	3.8339	3.0676
1962	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3	23.813	14.6281	12.1	15.7598	19.5788	16.0942	15.7007	14.8064	10.7202	10.4915	7.7822	11.8689	7.0496	6.1965
1962	4	10.213	5.9014	4.3323	8.9317	8.0056	3.6962	9.5156	8.3755	7.0111	7.7809	7.1126	4.7238	7.3276	6.3022
1962	5	1.857	3.015	2.0069	3.659	2.8342	1.6206	4.8057	3.7202	1.912	4.9331	4.6382	3.325	4.3313	7.3511
1962	6	3.1248	1.2822	0.6843	1.6799	1.3744	0.3417	1.5152	1.1196	0.4208	0.9713	0.6428	0.3068	0.2735	0.4701
1962	7	16.3112	5.6184	2.5333	8.4166	6.2625	1.2244	6.1466	3.9477	1.2581	3.1506	2.044	0.7978	0.7363	1.3926
1962	8	18.6006	9.3237	6.8411	11.8377	11.1786	4.8917	11.6416	10.4027	8.8239	9.442	8.6884	6.2812	9.2739	7.7909
1962	9	1.2874	2.4457	3.0683	2.5694	3.6961	3.0299	4.1433	4.9455	6.4704	4.7752	5.4085	4.5123	7.4429	5.2386
1962	10	20.6696	8.4217	3.3602	14.7353	9.6745	1.9357	11.1735	7.0774	2.1968	5.8153	3.5417	1.3699	1.2788	2.3065
1962	11	0.1419	0.0518	0.0299	0.0386	0.0533	0.0217	0.1094	0.0709	0.0247	0.1048	0.0677	0.0181	0.0141	0.0488
1962	12	2.9854	1.1731	0.6082	1.3744	1.4136	0.4416	2.3989	1.5836	0.5264	2.0494	1.3342	0.3333	0.2955	0.9278
1962	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	14	8.1654	10.3413	10.5051	8.0968	15.0061	16.9075	10.9981	12.724	11.0282	8.3751	6.6811	12.296	7.3896	5.661
1962	15	10.4039	18.6525	15.0122	17.9803	20.9266	22.0649	23.0189	20.9188	15.1474	16.8032	11.5707	17.6271	10.2813	9.386
1962	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	17	0.3895	0.1429	0.0627	0.2418	0.1745	0.0328	0.1702	0.112	0.0356	0.0765	0.0514	0.0206	0.0215	0.0345
1962	18	2.9466	2.6562	0.9295	4.7537	2.6195	0.7783	5.3715	3.4774	1.1816	3.5618	2.0728	0.7783	0.749	1.3695
1962	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	20	11.2445	5.4817	2.0337	9.2866	5.5456	1.1803	7.7406	4.6657	1.4202	4.0399	2.3119	0.9551	0.8483	1.4722
1962	21	1.7041	1.3839	0.54	2.0524	1.2809	0.4596	3.038	1.9134	0.624	2.3199	1.389	0.439	0.37	0.9357
1962	22	3.9265	2.3194	1.5057	2.5784	2.3602	1.0152	3.2217	2.4672	1.1545	3.0459	2.7748	1.8531	2.3736	4.0128
1962	23	9.3863	16.9743	14.6094	19.2074	21.4449	19.2271	26.6028	25.6255	21.4779	22.7131	19.1498	19.1097	20.2794	16.8825
1962	24	9.1608	3.7157	1.77	5.5917	4.5453	1.1705	6.1933	4.2632	1.4631	4.495	3.0549	1.0845	1.2162	2.4991
1962	25	21.7508	18.4353	12.3905	25.9449	19.7746	10.0499	28.4842	23.8596	20.4046	22.4209	20.1264	14.0912	22.2835	17.9384
1962	26	9.7585	15.9546	15.2119	12.3891	19.9735	22.1909	17.6103	18.8568	14.7899	14.3577	11.5408	18.7391	12.44	12.1103
1962	27	4.8612	6.1191	5.6312	6.3578	6.9826	4.7593	10.0728	9.7034	8.6057	11.0792	11.343	8.5449	12.8798	14.2002
1962	28	2.2041	0.8426	0.425	1.1725	1.0381	0.2802	1.5182	1.1089	0.4029	1.1741	0.7734	0.2455	0.273	0.5635
1962	29	11.4955	13.9171	13.6451	11.511	19.9903	22.0192	15.4932	17.8203	14.5691	11.573	9.1238	16.1824	9.964	7.6827
1962	30	5.5598	5.1697	3.7452	7.7671	6.1762	3.3622	8.6915	7.7253	6.7008	7.1563	6.5987	4.6947	7.5051	5.9483
1962	31	3.07	3.8869	4.0393	2.4842	5.2195	6.0399	4.4845	5.0223	3.977	3.8066	2.8983	4.7665	2.8407	2.452

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(4) Sample of daily precipitation data in April for 1960 -1962

Daily Precipitation Data on April for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	9.2186	3.5818	1.4358	4.8228	2.0884	0.5557	5.1833	2.5388	0.8085	2.948	1.6056	0.7857	0.801	1.2101
1960	2	0.1899	0.1364	0.0769	0.1993	0.0857	0.039	0.1763	0.0946	0.0414	0.1043	0.0788	0.0602	0.0488	0.0623
1960	3	3.7791	0.1647	0.1225	0.5506	0.1305	0.0966	0.4672	0.3728	0.2132	0.3067	0.2395	0.0994	0.1986	0.2288
1960	4	6.1886	5.1413	2.8571	6.8592	3.7883	1.7605	9.4009	6.984	4.2821	8.4005	7.7455	4.342	7.2063	9.5401
1960	5	7.0564	4.6663	4.2747	7.0537	7.2052	6.1299	8.8267	9.4672	6.9157	8.0273	7.8252	6.0541	7.6695	8.2904
1960	6	3.281	1.8358	1.1358	2.7088	0.8872	0.5639	1.065	0.3709	0.3577	0.4198	0.6262	0.9609	0.556	0.5458
1960	7	14.1976	0.7371	0.4419	2.4146	0.5939	0.2994	1.1602	0.9081	0.6679	1.1439	1.178	0.7616	1.1809	1.4874
1960	8	3.7257	1.7344	1.047	2.6321	0.8921	0.5282	1.1974	0.4726	0.3646	0.518	0.6545	0.8874	0.5399	0.5588
1960	9	2.4551	1.7301	0.8568	2.3799	1.3953	0.4583	2.1473	1.238	0.649	1.3122	1.0963	0.8799	1.0743	0.952
1960	10	2.0739	2.1693	1.3679	2.6507	2.6189	1.4091	2.7928	2.1484	1.4037	1.4559	1.3233	1.3312	1.4526	1.085
1960	11	2.7314	1.801	0.7222	2.0819	1.2478	0.2977	2.6136	1.4418	0.5597	1.5237	1.0021	0.5765	0.8162	0.8372
1960	12	1.154	0.7998	0.5288	1.3347	0.7636	0.4171	1.4386	1.2868	0.9565	1.6099	1.7093	1.0504	1.7296	2.1794
1960	13	2.1161	1.8143	0.8326	2.452	1.5746	0.4283	2.9266	1.7808	0.7774	1.8959	1.3675	0.8678	1.2466	1.1568
1960	14	7.168	2.782	1.7292	3.8973	1.4531	0.879	2.1586	0.988	0.6803	1.0508	1.1991	1.5182	1.0339	1.0489
1960	15	1.0805	0.7388	0.3532	0.9707	0.6147	0.1863	0.9405	0.5786	0.3085	0.5884	0.5009	0.41	0.5625	0.4588
1960	16	0.2593	0.0898	0.046	0.1662	0.0829	0.0232	0.3583	0.2455	0.0712	0.2479	0.1413	0.0224	0.0625	0.1111
1960	17	3.8181	1.6492	0.899	2.1632	0.6678	0.359	0.754	0.2374	0.21	0.2716	0.3714	0.6217	0.3313	0.3258
1960	18	7.0532	4.3035	1.9305	5.4328	2.5756	0.7844	7.5906	4.0797	1.2356	4.4097	2.459	1.1032	1.2364	1.9084
1960	19	2.0598	1.0815	0.4337	1.4429	0.8144	0.1819	3.0391	1.7726	0.4728	1.9052	0.9534	0.1984	0.4134	0.7267
1960	20	1.0203	0.6374	0.3171	1.0605	0.5882	0.1591	2.1765	1.47	0.4313	1.5468	0.8546	0.1954	0.4304	0.6655
1960	21	0.4622	0.1983	0.0969	0.3627	0.1955	0.0494	0.8066	0.5345	0.1479	0.5516	0.3035	0.0462	0.1278	0.2298
1960	22	0.0393	0.0228	0.0119	0.038	0.0213	0.0061	0.0909	0.0639	0.0184	0.0644	0.0363	0.0058	0.0162	0.0286
1960	23	4.2244	1.0419	0.617	1.4269	0.6817	0.3306	0.9507	0.5106	0.3276	0.5293	0.5426	0.6053	0.5554	0.4911
1960	24	0.508	0.3332	0.2528	0.5408	0.4138	0.2984	1.4761	1.5003	0.789	1.2211	0.9943	0.2401	0.7506	0.9178
1960	25	10.7047	1.9045	1.2624	3.7253	1.5837	0.8907	3.0403	2.7195	1.9712	3.3995	3.4636	2.2951	3.6359	4.5725
1960	26	2.1278	1.3973	0.5938	1.7254	0.9295	0.2359	3.1586	1.9376	0.5739	2.0054	1.0894	0.3241	0.6057	0.8777
1960	27	12.4015	10.9606	7.7489	12.7956	10.2511	6.8823	11.1905	8.3386	6.324	5.873	5.6702	7.5101	6.4532	4.8701
1960	28	2.694	2.4546	1.5546	2.9116	2.277	1.1117	4.6284	3.8269	1.9393	3.6656	2.3507	1.0906	1.6632	1.8711
1960	29	6.6867	5.9649	4.9855	8.861	7.4082	6.4239	11.4177	11.5733	7.8679	9.6251	9.0772	6.3359	8.1084	8.643
1960	30	0.7669	0.432	0.2803	0.65	0.2261	0.1483	0.2635	0.0993	0.0915	0.1097	0.1592	0.2447	0.142	0.1387
1961	1	0.7443	1.0187	0.339	1.8978	0.8718	0.3101	2.1352	1.3672	0.4424	1.4067	0.8257	0.342	0.2871	0.5591
1961	2	0.557	0.2405	0.1262	0.2242	0.2755	0.0905	0.6513	0.4247	0.1252	0.621	0.3986	0.0788	0.0789	0.2893
1961	3	9.4028	7.5063	5.2036	7.4857	6.3903	3.5556	10.0823	8.4455	8.2675	9.4197	8.2606	5.7982	9.9255	7.6259
1961	4	1.6158	1.1236	0.9787	1.6275	1.4721	0.8137	1.7734	1.8288	2.0167	1.6973	1.875	1.3358	2.472	1.8245
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	1.0546	1.7935	0.7017	3.4657	1.5775	0.5625	3.9702	2.5983	0.889	2.9585	2.1098	1.0077	1.3643	2.4129
1961	7	1.4684	0.5019	0.2036	0.9822	0.6164	0.0941	0.6322	0.4196	0.1124	0.275	0.1826	0.0648	0.0776	0.1274
1961	8	11.9368	9.5846	7.3066	9.9111	11.0093	8.8324	10.9319	10.4401	6.6138	7.9523	5.8421	7.8301	5.4753	4.9435
1961	9	17.0313	5.1927	2.0796	10.7507	6.7054	0.9746	6.9978	4.5479	1.1397	3.0599	1.9347	0.6755	0.7763	1.2979
1961	10	3.1719	2.4925	1.2673	3.6127	2.1996	0.856	3.8698	2.6768	0.9929	2.941	2.0699	1.3018	1.4882	2.4088
1961	11	4.2293	2.0189	1.2556	1.0971	1.4824	0.6123	2.5117	1.5833	0.5257	2.4442	1.3759	0.6401	0.3886	0.9885
1961	12	17.8863	6.552	3.7894	13.2464	9.149	2.713	10.2622	8.5242	5.8987	6.7778	6.3536	3.6702	6.7598	5.6934
1961	13	0.2355	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	10.2801	3.0673	1.2192	6.8656	4.1938	0.6103	4.4498	2.9877	0.7458	1.9403	1.2671	0.4045	0.5064	0.8582
1961	15	0.2792	0.4001	0.1157	0.8811	0.3506	0.0978	0.9624	0.6	0.1597	0.6214	0.3331	0.1153	0.1137	0.2199
1961	16	4.7494	2.4324	0.83	5.5176	2.7482	0.5297	4.7717	3.0501	0.767	2.6601	1.4983	0.4906	0.5286	0.9834
1961	17	18.9716	5.6217	2.4961	12.6574	8.1625	1.4371	8.0678	5.8142	1.6461	3.5692	2.4281	0.9204	1.0562	1.6564
1961	18	3.3703	1.3864	0.8099	0.5029	0.6613	0.2275	0.7098	0.2961	0.095	0.6278	0.1622	0.2938	0.1195	0.1066
1961	19	11.3522	5.3001	3.0274	2.1334	2.5356	0.8574	2.9352	1.2863	0.3964	2.5302	0.7013	1.1008	0.4667	0.4584
1961	20	3.3946	3.6961	4.0632	5.0565	5.3788	3.8565	7.0396	8.4493	10.4801	8.248	9.4064	6.6622	13.2152	9.3331
1961	21	8.2282	3.1618	1.5893	3.6708	2.7437	0.5669	2.9021	1.7456	0.4579	1.6963	0.7789	0.547	0.3794	0.5237
1961	22	14.8199	5.1474	2.1999	11.7696	7.128	1.385	8.2028	5.9137	1.6589	4.058	2.5772	0.989	1.0628	1.7298
1961	23	0.786	1.1297	1.3603	1.4107	1.6679	1.3306	2.2116	2.7885	3.464	2.7626	3.1428	2.291	4.4079	3.149
1961	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	25	7.5107	16.0247	18.5187	11.6974	25.9185	34.509	19.0822	25.9787	21.4091	16.4719	12.6231	25.273	15.1435	11.1048
1961	26	2.4996	1.8024	1.6698	1.8151	2.178	1.3971	3.5048	3.4619	3.1987	4.0012	3.5884	2.2061	3.8859	3.3401
1961	27	0.3468	0.8157	0.6719	0.9383	0.8162	0.5272	1.3544	1.3128	0.7421	1.905	2.0687	1.3705	2.1886	3.6738
1961	28	8.6133	2.8233	1.35	5.741	3.7994	0.7217	3.6304	2.6793	0.7722	1.6813	1.1055	0.4736	0.5063	0.7725
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	1.8982	2.7621	0.82	6.3776	2.5208	0.715	6.9531	4.528	1.1504	4.6647	2.3921	0.8189	0.8003	1.5547
1962	1	0.7036	0.2548	0.1139	0.4448	0.3087	0.0588	0.3066	0.207	0.0659	0.1391	0.0998	0.0413	0.0484	0.0803
1962	2	0.7852	0.3007	0.142	0.5341	0.401	0.0899	0.4753	0.3565	0.1297	0.3024	0.2197	0.0776	0.1049	0.1889
1962	3	0.6957	0.2508	0.1123	0.4404	0.3042	0.0579	0.3036	0.2055	0.065	0.1381	0.0987	0.0409	0.048	0.0796
1962	4	7.3247	8.3889	8.234	6.6795	11.498	12.2072	9.0731	10.2292	7.7937	7.0044	5.4638	9.8193	6.3469	5.3911
1962	5	12.2949	15.943	12.7725	17.8819	19.1111	16.4015	24.6988	22.4193	15.8928	20.9074	16.5452	16.3196	16.0909	15.9061
1962	6	2.6068	1.4161	1.0266	1.4897	1.6219	0.6053	2.6983	2.3504	0.9843	2.7354	1.9129	1.1055	0.8629	1.7301
1962	7	15.8307	30.6567	31.5119	20.5617	41.8455	52.0934	33.312	39.4909	31.6163	28.1729	21.0284	40.1612	24.8414	20.6609
1962	8	5.5288	5.1386	5.5299	6.6777	7.0493	4.3162	10.0488	10.149	9.1217	10.6987	10.2964	7.9641	11.737	10.4866
1962	9	13.5034	26.5957	29.8649	17.5011	38.9998	47.2325	31.74	39.2803	32.5982	28.9703	24.0113	39.6782	29.5681	24.4588
1962	10	3.8875	4.7084	1.803	7.3569	3.3937	1.2236	7.9919	5.104	1.6482	5.3485	3.0842	1.5378	1.2575	2.475
1962	11	5.1816	2.2892	0.9043	4.4416	2.623	0.5693	3.5097	2.2983	0.6992	1.9173	1.2055	0.4896	0.5249	0.9386
1962	12	5.0107	8.5149	9.1016	5.7742	12.4877	14.7644	10.7004	12.6653	9.4424	9.4549	7.3069	11.6241	7.7812	7.2207
1962	13	0.3897	0.5689	0.4887	1.0031	0.4337	0.1538	1.0485	0.6531	0.2093	0.7034	0.3953	0.5718	0.1841	0.3101
1962	14	2.8688	4.7	4.308	4.3088	6.0087	6.4645	5.963	6.2052	4.2495	4.7251	3.4072	5.411	3.5643	3.2749
1962	15	10.603	7.4357	6.7162	9.7136	9.3749	5.5204	11.2519	11.7488	11.3042	11.0869	11.5933	8.9618	14.9438	12.1198
1962	16	10.4626	9.7469	6.2246	14.6572	9.7433	4.8906	16.0625	13.2324	8.9795	12.8988	10.6857	7.8027	10.9537	10.4625
1962	17	4.9178	2.8536	2.0799	1.4624	1.7017	0.7712	1.9343	1.903	0.7715	1.6693	1.2114	1.0068	0.6567	1.2426
1962	18	9.9673	9.1811	8.6568	11.0516	13.1968	10.3658	15.5017	16.1787	13.2284	15.1274	13.8605	11.9164	15.6392	13.969
1962	19	8.3779	14.396	14.4171	10.0145	19.1862	23.339	15.7233	18.889	14.091	13.4028	9.8606	17.7611	11.5753	9.8085
1962	20	10.8874	6.009	4.4533	8.0477	6.8564	3.0826	9.25	8.2121	5.4338	8.3265	6.9755	4.76	6.5842	6.856
1962	21	4.9603	6.7939	7.2171	5.2589	9.978	11.4866	7.7915	9.5151	7.0762	6.4828	4.8948	9.1028	5.9351	4.9111
1962	22	6.5143	2.7935	1.2128	4.8043	3.0385	0.7316	4.3294	2.901	0.8619	2.7618	1.709	0.6405	0.639	1.3666
1962	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	24	8.5281	14.9895	16.8797	9.2846	21.1139	26.8835	15.6074	20.5304	15.8888	13.6776	10.3192	21.29	13.0592	10.5405
1962	25	0.044	0.024	0.0155	0.0484	0.0497	0.0176	0.0906	0.0854	0.0349	0.093	0.0656	0.0205	0.0319	0.0602
1962	26	1.3147	2.815	3.2162	1.9451	4.3812	5.4346	3.3403	4.3885	3.3397	3.0093	2.2949	4.2266	2.8248	2.3142
1962	27	1.4804	3.1617	3.6394	2.1466	4.8457	6.0447	3.679	4.8718	3.7014	3.2876	2.521	4.7327	3.1163	2.5619
1962	28	12.445	4.9149	2.6713	5.9974	4.4638	1.0981	3.984	3.1487	0.9991	2.0424	1.3917	0.9875	0.7373	1.2713
1962	29	15.8084	8.4513	4.3644	11.7739	7.5905	2.1716	10.6363	7.9565	2.4718	7.1128	4.2763	2.3874	1.837	3.5831
1962	30	12.2567	14.0647	14.7851	13.1649	20.1338	19.1201	23.3146	26.3709	20.1261	26.0389	21.3755	19.9944	22.0975	21.4479

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(5) Sample of daily precipitation data in May for 1960 -1962

Daily Precipitation Data on May for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	1.1767	0.7593	0.4488	1.2135	0.6284	0.2548	2.0413	1.4309	0.4636	1.4566	0.8985	0.3402	0.4616	0.7062
1960	2	5.7692	4.5981	3.1575	7.0064	3.0891	2.0201	5.2828	3.928	2.8147	4.5983	4.9448	4.0164	4.8634	5.8977
1960	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	4	3.0976	1.7773	0.5123	2.4939	1.1421	0.1788	3.5998	1.9896	0.489	2.2787	1.0171	0.164	0.4014	0.735
1960	5	3.196	2.4578	1.4103	2.9389	1.1051	0.6114	1.1559	0.401	0.357	0.4456	0.6171	1.0343	0.5573	0.5435
1960	6	0.6659	0.4858	0.3081	0.7592	0.3227	0.1727	0.6314	0.3832	0.1697	0.4127	0.3162	0.2626	0.2084	0.2541
1960	7	9.9696	3.0487	0.8692	4.6858	1.9532	0.3037	6.2183	3.4297	0.8337	3.9233	1.7309	0.2764	0.6768	1.2431
1960	8	2.9481	1.4577	0.9892	2.1604	0.8432	0.5585	1.5745	0.9459	0.5029	0.9614	0.8823	0.8908	0.6599	0.7571
1960	9	3.5876	3.2477	2.2372	5.4006	3.263	1.788	6.6893	6.4006	4.1502	7.7466	7.336	4.0145	7.1882	9.3949
1960	10	2.6057	2.2953	1.5695	3.8543	2.2842	1.2462	4.0079	3.8169	2.663	4.7608	4.7159	2.7704	4.6526	5.9633
1960	11	2.6438	2.0862	1.4396	3.0813	1.0981	0.8016	1.2865	0.5384	0.506	0.5929	0.8562	1.3146	0.7821	0.7554
1960	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	13	2.5706	0.9454	0.4132	1.3072	0.6264	0.1633	2.5518	1.7238	0.47	1.7178	0.8892	0.1563	0.3914	0.6999
1960	14	23.6091	18.941	9.2849	23.2934	8.2309	3.6676	8.0204	2.9079	2.1205	3.3087	3.7513	6.0312	3.1451	3.1703
1960	15	0.5366	0.3912	0.1814	0.4753	0.2749	0.0771	0.8343	0.5723	0.1811	0.5681	0.3244	0.1119	0.1972	0.2664
1960	16	1.6501	1.0672	0.4667	1.3321	0.7096	0.1855	2.8709	1.9663	0.5351	1.9476	1.0087	0.1764	0.4418	0.7913
1960	17	2.3512	1.3177	0.5717	1.7737	1.0816	0.2612	3.9823	2.6642	0.7066	2.7304	1.3556	0.2689	0.5845	1.0261
1960	18	0.67	0.5014	0.3435	0.74	0.3016	0.1993	0.5659	0.3632	0.1873	0.3613	0.323	0.3088	0.235	0.2743
1960	19	0.4713	0.4045	0.323	0.5844	0.316	0.3606	0.3381	0.2434	0.3429	0.1882	0.3092	0.3777	0.3181	0.2608
1960	20	0.3	0.1929	0.073	0.2442	0.1359	0.0289	0.4706	0.3042	0.0806	0.3083	0.1566	0.0265	0.0649	0.1174
1960	21	4.3216	3.7313	2.5931	5.5332	3.2727	1.9192	5.8277	5.9274	4.4381	7.2583	7.662	4.9725	8.178	10.4905
1960	22	2.7102	2.106	1.5063	2.6031	2.1681	1.3566	3.5758	3.3505	1.7978	3.035	1.9866	1.3557	1.5503	1.6337
1960	23	5.3954	3.5301	2.6731	4.3605	3.1069	2.4716	5.8222	5.2836	3.2392	4.1944	3.4592	2.5869	2.8508	2.9899
1960	24	0.9503	0.8301	0.7084	0.9439	0.692	0.566	2.0117	2.1099	1.1314	1.7308	1.1719	0.5615	1.0054	1.1064
1960	25	5.7139	3.5141	2.448	5.4711	1.8748	1.3912	2.1415	0.9371	0.8801	1.0072	1.4707	2.2331	1.3179	1.2812
1960	26	1.7123	0.438	0.3507	0.8931	0.3687	0.4152	0.429	0.3419	0.4393	0.2599	0.4112	0.4162	0.3994	0.3451
1960	27	3.4016	1.9687	0.8672	2.6489	1.6074	0.4035	5.8194	3.9725	1.0512	3.9978	2.0135	0.4227	0.8594	1.508
1960	28	2.9904	3.3318	3.2412	5.1474	5.5953	4.976	9.7396	12.1246	7.4372	9.2938	8.3046	4.334	7.3887	8.4589
1960	29	1.4198	0.1457	0.0923	0.4393	0.1141	0.0556	0.3074	0.2205	0.08	0.2145	0.1469	0.0764	0.0815	0.1152
1960	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	31	0.1098	0.0693	0.0396	0.1193	0.073	0.0232	0.2965	0.249	0.0727	0.2328	0.1364	0.021	0.0598	0.1061
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	4.3045	5.6844	5.5436	4.3261	7.425	8.1746	6.6899	8.0598	5.7068	6.1636	4.59	6.9149	4.8353	4.0909
1961	3	1.0696	0.4675	0.2881	0.1774	0.2365	0.0867	0.2488	0.1123	0.0361	0.2327	0.0602	0.1094	0.045	0.04
1961	4	2.6979	5.3927	5.864	4.0396	8.0569	9.5389	6.6178	8.8605	6.615	6.2554	5.0172	7.8824	5.555	4.5705
1961	5	0.0495	0.1825	0.154	0.2121	0.1899	0.1245	0.306	0.3079	0.1744	0.4397	0.4729	0.315	0.5004	0.8334
1961	6	7.8069	2.3794	1.0241	5.5612	3.4969	0.5475	3.6129	2.6684	0.6632	1.7092	1.0951	0.3549	0.4463	0.7499
1961	7	4.0831	1.3605	0.6695	2.954	2.0553	0.4299	2.1466	1.698	0.4984	1.1919	0.7982	0.2827	0.32	0.5635
1961	8	2.2866	0.835	0.4043	1.6627	1.0861	0.2168	1.1186	0.8668	0.264	0.6529	0.4936	0.2458	0.3387	0.5514
1961	9	0.7861	1.4748	1.8597	1.8815	2.3237	1.9016	2.9351	3.9674	4.9837	3.8634	4.3516	3.1958	6.1743	4.3541
1961	10	5.2187	8.7858	6.6855	13.9877	9.6919	5.9143	17.1329	16.6651	13.0255	18.5831	17.5974	11.6236	20.0402	22.6717
1961	11	11.8666	4.1577	2.1628	7.9711	5.9612	1.3759	6.6105	5.3055	1.607	4.3891	2.8569	0.979	1.0291	2.0542
1961	12	27.1717	16.9256	12.5775	13.1238	13.0929	7.5779	18.2838	17.0926	15.6658	20.4225	16.7609	12.6624	20.2251	17.3844
1961	13	2.5824	0.8377	0.3706	1.905	1.234	0.2017	1.2631	0.9661	0.2451	0.6185	0.3979	0.1303	0.1632	0.2732
1961	14	1.6492	0.5217	0.2321	1.1774	0.767	0.1268	0.7853	0.6041	0.1542	0.3874	0.2496	0.082	0.1027	0.1717
1961	15	0.3226	0.5023	0.1717	1.1182	0.503	0.1902	1.1506	0.8732	0.2695	0.8276	0.4631	0.2004	0.1766	0.313
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0.8356	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	23	2.7514	5.8028	6.4798	4.378	9.1632	10.9971	7.1314	10.2227	7.68	6.9388	5.5966	8.7107	6.0828	5.0224
1961	24	0.1038	0.2037	0.1903	0.2285	0.2532	0.1732	0.3428	0.3769	0.199	0.476	0.493	0.3631	0.5294	0.8503
1961	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	2.6336	0.9267	0.456	1.7868	1.3039	0.2828	1.3986	1.1106	0.361	0.8486	0.5533	0.2109	0.2593	0.4085
1962	2	10.3436	3.362	1.6619	5.669	4.2444	0.9366	4.7195	3.3758	0.9945	3.0226	1.8605	0.6541	0.6484	1.3231
1962	3	28.0678	19.8648	16.5721	23.4762	26.5208	22.5104	24.7359	25.4642	15.3263	18.023	12.2173	17.248	10.8587	9.8831
1962	4	6.5568	6.9864	4.4578	10.8414	8.4183	6.2168	11.5735	10.0715	4.8916	8.3898	5.0927	4.9672	3.483	3.8321
1962	5	16.1202	5.2023	2.5018	9.0401	6.2912	1.1755	5.7302	4.19	1.2027	2.6512	1.68	0.7638	0.7836	1.1839
1962	6	13.4737	6.7324	5.7228	11.2016	10.3228	5.1055	10.8409	11.6408	9.9432	9.5114	9.2697	6.7699	11.4957	8.7132
1962	7	3.0482	1.0327	0.4979	2.0252	1.4195	0.2775	1.3805	1.0558	0.308	0.6718	0.4368	0.1783	0.2005	0.3065
1962	8	4.4613	7.8324	9.3039	8.929	12.6867	11.9117	13.5608	17.6346	17.5036	14.8916	14.5872	13.7439	19.407	13.9169
1962	9	3.732	8.2397	10.0219	5.7021	13.8394	18.5095	9.6797	13.9511	11.308	8.7158	6.6257	13.0699	8.0878	5.8969
1962	10	0.6483	1.3759	1.6591	0.9734	2.2764	2.9284	1.6338	2.3271	1.838	1.4872	1.1376	2.1429	1.3575	1.017
1962	11	0.494	0.2064	0.1299	0.1937	0.2672	0.1163	0.5839	0.4558	0.1432	0.6357	0.4031	0.0948	0.0866	0.2978
1962	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	17	3.197	6.8974	8.4099	5.0525	12.2313	15.953	8.5237	12.489	10.0115	7.8909	6.0929	10.9319	7.3029	5.7034
1962	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	19	1.1593	2.4528	2.9958	1.803	4.3529	5.5991	3.0254	4.4653	3.5622	2.7817	2.1332	3.8508	2.5256	1.8904
1962	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	23	2.106	4.5656	5.6147	3.3415	8.248	10.7707	5.6308	8.4596	6.8163	5.1788	3.9792	7.2421	4.7194	3.5068
1962	24	0.1697	0.0736	0.0467	0.069	0.0975	0.0429	0.2068	0.1692	0.0532	0.2299	0.1475	0.0343	0.0313	0.1079
1962	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	26	5.9904	12.5812	13.3955	12.1896	21.0731	26.1516	17.6531	23.1657	17.081	15.2853	10.9325	17.362	11.3311	9.1019
1962	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont'd)

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(6) Sample of daily precipitation data in June for 1960 -1962

Daily Precipitation Data on June for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	3	4.9871	3.9072	2.7603	5.8536	2.2466	1.6783	3.416	2.0167	1.3176	1.9793	2.2316	2.6014	1.7521	1.9017
1960	4	1.4186	1.125	0.8034	1.6624	0.6283	0.4954	0.7874	0.3978	0.3439	0.4038	0.5678	0.7751	0.4884	0.493
1960	5	0.5044	0.4014	0.2879	0.591	0.2231	0.1789	0.2617	0.1235	0.1198	0.1272	0.196	0.28	0.1736	0.1712
1960	6	0.3044	0.2003	0.0911	0.2537	0.1419	0.0391	0.552	0.4088	0.1124	0.3862	0.2099	0.036	0.0905	0.1634
1960	7	2.7445	2.9059	2.1393	4.9288	3.2044	1.9366	6.0245	6.5808	4.7015	7.5891	8.1996	4.5645	8.214	10.7919
1960	8	0.5445	0.489	0.3439	0.8319	0.5462	0.2921	1.321	1.3147	0.7176	1.3793	1.2426	0.5942	1.0701	1.4338
1960	9	0.0743	0.0467	0.0275	0.0828	0.0519	0.0172	0.2113	0.184	0.0541	0.1685	0.1017	0.0153	0.0444	0.0791
1960	10	0.6285	0.378	0.235	0.6404	0.3569	0.1514	1.1449	0.9381	0.2989	0.8829	0.5627	0.1822	0.2716	0.4304
1960	11	0.1205	0.0756	0.0446	0.1348	0.0844	0.0281	0.3456	0.3016	0.0884	0.2759	0.1667	0.0249	0.0725	0.1293
1960	12	0.2022	0	0	0.0393	0	0	0.0022	0	0	0	0	0	0	0
1960	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	15	2.4136	1.9102	1.321	3.135	1.1752	0.819	1.4094	0.6397	0.5315	0.673	0.9443	1.2221	0.7525	0.7712
1960	16	1.1285	0.8547	0.6078	1.323	0.5534	0.3886	1.0539	0.7383	0.3743	0.7017	0.652	0.5713	0.4511	0.5412
1960	17	0.1286	0.0954	0.0678	0.1493	0.0638	0.044	0.1253	0.0899	0.0443	0.0853	0.0772	0.0642	0.0526	0.064
1960	18	0.3968	0.313	0.2297	0.4727	0.1788	0.1476	0.2129	0.1029	0.0986	0.1053	0.1634	0.227	0.1428	0.1418
1960	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	22	0.0253	0.0156	0.0095	0.0285	0.018	0.0062	0.0737	0.0653	0.0191	0.0597	0.0362	0.0054	0.0157	0.0281
1960	23	0.1613	0.0995	0.0604	0.1823	0.1149	0.0394	0.4755	0.4211	0.1226	0.3851	0.2326	0.0342	0.1005	0.18
1960	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	26	1.4916	1.1657	0.8751	1.7884	0.6703	0.5686	0.8016	0.3886	0.3721	0.3985	0.6176	0.8679	0.542	0.5362
1960	27	1.203	1.0098	0.7703	1.6048	0.7822	0.5803	1.1252	0.9724	0.7573	1.0791	1.2646	1.0245	1.2155	1.4622
1960	28	1.693	1.3109	0.9859	2.0256	0.774	0.643	1.0278	0.5583	0.449	0.5589	0.7527	0.9709	0.6298	0.6472
1960	29	8.6395	6.8305	4.3159	8.7401	3.0761	2.0227	3.2733	1.3404	1.1552	1.4288	1.9583	3.1428	1.6847	1.6756
1960	30	3.5946	2.0027	1.1279	2.961	1.8447	0.731	5.2827	4.2243	1.6513	4.3633	2.9884	1.1732	2.0331	2.9429
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	1.8463	0.6305	0.2929	1.4414	0.9695	0.1717	0.9405	0.7921	0.2161	0.4822	0.3457	0.1151	0.157	0.2729
1961	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	1.8828	4.3222	5.0444	3.373	7.4122	9.1519	5.7497	8.7128	6.393	5.8143	4.8724	7.1471	5.4442	4.8287
1961	23	1.8799	4.3102	5.0453	3.368	7.4143	9.171	5.7492	8.7237	6.3996	5.8219	4.8762	7.1521	5.4499	4.8327
1961	24	2.3004	5.2978	6.221	4.1324	9.1441	11.3693	7.0734	10.7599	7.9015	7.1677	5.9955	8.8291	6.7167	5.9426
1961	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	27	1.0999	0.578	0.3982	0.2296	0.3263	0.1406	0.3227	0.1734	0.0598	0.3343	0.0963	0.1731	0.0777	0.0721
1961	28	0.1722	0.0829	0.0527	0.0947	0.1267	0.0521	0.2878	0.2498	0.0739	0.3401	0.2372	0.0425	0.0506	0.1962
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	5	1.69	0.8419	0.6111	0.6605	0.7568	0.4137	1.3235	1.1095	0.3675	1.5055	0.9941	0.4784	0.3329	0.8826
1962	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	7	23.2747	16.1452	5.9029	35.8184	19.2666	5.3018	31.905	24.9693	7.3793	20.8724	12.6346	4.717	4.898	9.4519
1962	8	14.894	14.3029	7.2745	27.3953	18.4138	9.9169	30.2996	26.5406	10.1322	22.8434	14.5354	7.9024	6.8654	11.6604
1962	9	7.298	20.6531	26.8492	14.1873	41.1353	57.7133	26.9527	43.1174	34.5758	25.2017	19.4162	35.2932	23.7188	19.1176
1962	10	5.7871	9.619	3.2097	21.0651	9.8208	3.7245	22.1909	17.8367	5.6415	16.2067	9.5813	3.846	3.8307	7.6295
1962	11	1.2537	1.777	0.6704	3.7197	2.0518	0.793	4.2677	3.6192	1.2484	3.4959	2.206	0.8265	0.9258	1.7739
1962	12	6.3075	7.5996	8.9278	8.0654	13.5608	13.4283	11.1898	16.4781	14.3653	11.8558	11.554	12.3971	14.8182	11.8808
1962	13	0.809	2.0636	2.6204	1.4969	3.9588	5.1335	2.7415	4.2934	3.2882	2.6107	2.0622	3.4689	2.4394	2.0536
1962	14	12.7823	13.0531	14.4404	12.1982	22.4798	25.0501	15.976	22.1135	15.6754	13.2621	10.2354	17.0048	11.2481	9.7615
1962	15	1.6675	4.1636	5.3041	3.0079	8.002	10.5284	5.4492	8.6243	6.6444	5.1832	4.0837	7.02	4.8949	4.0752
1962	16	0	0	0	0.0062	0	0	0.1008	0.0526	0	0.1172	0.0765	0	0	0.0228
1962	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	18	0.2311	0.3655	0.1332	0.6904	0.3434	0.1384	0.7371	0.5871	0.1926	0.5539	0.3325	0.1481	0.1382	0.2618
1962	19	0.0538	0.0401	0.0331	0.0125	0.0186	0.0112	0.0073	0.0093	0.0047	0.0021	0.0024	0.011	0.0057	0.0036
1962	20	28.0297	12.6229	9.4777	18.4511	15.7766	6.6299	14.7479	15.3283	9.6634	11.923	10.4023	8.398	11.3068	10.1807
1962	21	6.6165	5.9364	6.2588	6.478	10.5775	10.9788	7.7015	10.6088	7.1884	6.2997	4.8981	7.4069	5.3547	4.789
1962	22	1.4505	2.1564	2.5517	3.2113	3.7686	2.9564	7.1687	7.6658	6.2449	8.749	8.052	4.2784	7.6027	6.6854
1962	23	3.0154	6.3151	8.0859	4.9082	12.6001	16.4493	8.639	13.5749	10.3227	8.1061	6.3473	10.6216	7.4711	6.278
1962	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	25	0.0797	0.0614	0.051	0.0489	0.034	0.0292	0.0017	0.0104	0.0075	0	0.0012	0.0465	0.0235	0.011
1962	26	1.5752	2.6086	3.1415	1.9545	4.3226	5.5849	2.7584	4.4812	3.4142	2.6561	2.1049	4.0026	2.7273	2.1952
1962	27	2.8872	5.4258	6.7791	4.0077	9.6595	12.8291	6.2341	10.1571	7.813	6.0007	4.7202	8.7973	6.0079	4.8457
1962	28	8.8294	25.2004	35.3754	18.3257	54.5878	77.314	36.4321	60.6934	49.1819	36.7002	29.7928	48.0065	36.8107	29.4337
1962	29	2.285	5.9109	7.9216	4.3136	12.1008	16.4962	8.1576	13.211	10.204	7.8926	6.159	10.5703	7.3919	6.1227
1962	30	11.1246	27.7829	37.5869	18.3134	54.0655	80.613	33.8226	55.347	44.6203	32.4419	24.2576	50.8975	31.3276	23.6795

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(7) Sample of daily precipitation data in July for 1960 -1962

Daily Precipitation Data on July for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	2.6282	1.81	1.2135	3.3606	2.1503	0.9822	5.9854	5.3587	2.363	5.6336	4.2752	1.759	3.1542	4.3736
1960	2	9.9488	5.3102	3.5134	7.2367	5.4332	2.737	11.8737	11.0222	5.2262	10.0506	6.1735	2.3968	3.948	4.5216
1960	3	0.1589	0.1031	0.0684	0.1734	0.0868	0.0418	0.2645	0.2098	0.067	0.2002	0.124	0.051	0.0624	0.0953
1960	4	0.4377	0.2575	0.1492	0.473	0.2868	0.0902	1.1883	0.9789	0.2626	0.9279	0.505	0.0748	0.2076	0.3762
1960	5	0.253	0	0	0.048	0	0	0.0026	0	0	0	0	0	0	0
1960	6	2.9921	1.6462	0.9879	2.1911	0.8439	0.4618	1.636	0.9776	0.4022	0.9732	0.7128	0.6552	0.4522	0.5683
1960	7	1.7434	0.9562	0.3568	1.3323	0.7195	0.1552	2.5692	1.682	0.4121	1.6993	0.8109	0.1282	0.3147	0.583
1960	8	3.6361	2.79	2.0638	4.3033	1.5566	1.2185	1.9733	0.9807	0.7556	0.9905	1.2677	1.7934	1.0396	1.0607
1960	9	1.7064	1.163	0.8027	1.9071	0.8869	0.4864	2.4184	1.8419	0.6358	1.765	1.1526	0.6225	0.6255	0.8946
1960	10	0.1435	0.1103	0.0825	0.1678	0.0619	0.0498	0.0716	0.0329	0.0296	0.0337	0.0486	0.073	0.0417	0.0411
1960	11	0.1435	0.1103	0.0826	0.1676	0.0619	0.0499	0.0716	0.0329	0.0296	0.0337	0.0485	0.0731	0.0417	0.0411
1960	12	0.6303	0.4507	0.3232	0.7141	0.3066	0.1961	0.6611	0.4696	0.1951	0.4533	0.3414	0.2662	0.213	0.2719
1960	13	2.1799	1.6814	1.259	2.564	0.928	0.7509	1.0666	0.485	0.4387	0.4967	0.7167	1.1052	0.6194	0.608
1960	14	0.0734	0.0556	0.0417	0.0853	0.0315	0.0254	0.0366	0.0168	0.0151	0.0172	0.0247	0.0373	0.0213	0.021
1960	15	1.4184	1.0938	0.8206	1.6614	0.6066	0.492	0.6962	0.3178	0.2881	0.3251	0.4675	0.7219	0.4053	0.3972
1960	16	3.0545	2.3606	1.7686	3.5916	1.2971	1.0537	1.484	0.6737	0.6118	0.6893	0.9919	1.5495	0.8622	0.8436
1960	17	1.668	1.2878	0.9661	1.952	0.7129	0.5793	0.8159	0.3722	0.3383	0.3805	0.5461	0.8494	0.4751	0.4648
1960	18	0.3475	0.2043	0.1203	0.371	0.2296	0.074	0.932	0.7743	0.2121	0.7331	0.3923	0.0605	0.1652	0.2952
1960	19	0.0735	0.0557	0.0419	0.085	0.0316	0.0256	0.0364	0.0167	0.0152	0.0171	0.0244	0.0375	0.0213	0.0208
1960	20	0.0735	0.0558	0.0419	0.0849	0.0316	0.0256	0.0364	0.0167	0.0152	0.0171	0.0244	0.0375	0.0213	0.0208
1960	21	0.1438	0.1109	0.0832	0.1665	0.0622	0.0506	0.0711	0.0327	0.0299	0.0334	0.0475	0.0737	0.0416	0.0406
1960	22	0.5926	0.458	0.3428	0.6879	0.2552	0.2075	0.2907	0.1333	0.122	0.1359	0.1939	0.3029	0.1699	0.1658
1960	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	24	0.8955	0.0806	0.0562	0.1293	0.0606	0.0348	0.1521	0.1157	0.0428	0.1106	0.0736	0.045	0.0425	0.0584
1960	25	1.1133	0.056	0.0417	0.0847	0.0316	0.0256	0.0362	0.0166	0.0152	0.017	0.0241	0.0375	0.0212	0.0207
1960	26	1.8853	2.0785	2.1854	3.1148	3.532	3.5032	3.7841	5.0029	3.6805	3.8571	3.6028	3.0771	3.6671	3.7995
1960	27	1.9055	1.4269	1.2208	2.2936	1.5823	1.5908	3.5719	4.074	2.5537	3.1006	2.7001	1.3782	2.1537	2.3389
1960	28	0.1797	0.1152	0.0757	0.191	0.1008	0.0474	0.3129	0.2524	0.0811	0.2397	0.1414	0.0553	0.0719	0.1104
1960	29	0.5497	0.3247	0.1877	0.5834	0.3615	0.116	1.4601	1.2066	0.3349	1.14	0.605	0.0949	0.258	0.4597
1960	30	0.0236	0.0139	0.0081	0.0249	0.0155	0.005	0.0611	0.0508	0.0143	0.048	0.0257	0.0041	0.0111	0.0196
1960	31	0.7716	0.598	0.4385	0.8922	0.3307	0.2667	0.3734	0.1699	0.1576	0.1728	0.2462	0.3901	0.2182	0.2126
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	7	5.6236	1.7829	0.8334	4.2795	2.9036	0.4995	2.9237	2.4351	0.5883	1.474	0.9313	0.2855	0.3537	0.6008
1961	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	1.9423	3.74	4.323	3.1317	6.137	7.2819	5.1553	7.4835	5.2899	5.7536	4.9368	6.1148	5.1163	5.5295
1961	11	0.0652	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0.0172	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	23	0.1016	0.0485	0.0334	0.0535	0.0778	0.0375	0.1648	0.1471	0.0458	0.1918	0.1213	0.027	0.0244	0.0852
1961	24	1.6459	3.1352	3.4935	3.0253	5.2766	6.3181	4.5808	6.4005	4.4677	4.4308	3.3128	4.7112	3.2831	2.8201
1961	25	0.0745	0.275	0.2562	0.3313	0.3334	0.2349	0.4898	0.5656	0.3187	0.7524	0.7832	0.5186	0.7995	1.3182
1961	26	1.2842	2.4877	3.0196	1.9597	4.3719	5.5369	3.2593	5.0532	3.8239	3.32	2.6259	4.1013	2.8324	2.3159
1961	27	1.8054	3.5703	4.3258	2.8009	6.2701	7.9778	4.6591	7.2323	5.4955	4.7375	3.7449	5.8898	4.0541	3.3039
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0.0333	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	0	1.9298	1.9724	0	0	0.7041	0	0	0	0	0	1.486	0.0896	0
1962	2	11.3671	25.8366	34.739	18.5751	52.4135	79.9931	32.8131	54.7197	47.3688	30.9397	23.761	46.9137	28.3211	19.859
1962	3	9.7995	22.3973	30.0048	15.9139	44.4105	66.9536	28.0554	46.594	39.828	26.5591	20.404	40.1853	24.1812	17.0878
1962	4	3.0131	3.2947	3.8274	2.3399	4.5076	5.8797	3.0314	4.5796	3.4577	3.0037	2.0829	4.3639	2.4825	1.8135
1962	5	3.6176	4.0591	3.5631	5.6457	6.3854	6.2027	6.7524	7.667	4.412	5.4636	3.588	4.2122	2.8249	2.684
1962	6	0.9962	0.3391	0.1731	0.7103	0.5407	0.1134	0.5144	0.4459	0.1264	0.2713	0.174	0.0629	0.0725	0.1139
1962	7	11.3682	17.9101	23.0402	14.8048	35.6426	49.3216	23.3112	37.0141	30.1176	21.3521	16.2588	29.8422	18.4795	13.4846
1962	8	0	0.456	0.4742	0	0	0.1724	0	0	0	0	0	0.3604	0.0219	0
1962	9	4.7362	1.551	0.7847	3.3026	2.5091	0.5131	2.3528	2.033	0.5686	1.2218	0.7772	0.28	0.3213	0.5052
1962	10	0	0.9851	1.0277	0	0	0.3737	0	0	0	0	0	0.7783	0.047	0
1962	11	6.2712	13.5205	18.3593	9.9996	27.4518	40.1503	17.549	29.0313	24.2985	16.8352	12.8501	24.4438	15.1074	10.8545
1962	12	3.2487	6.7241	9.0793	5.1043	13.6225	19.2508	8.8967	14.5552	11.8927	8.5972	6.5781	12.0108	7.608	5.5827
1962	13	4.2399	8.5993	10.9966	7.0888	16.3129	21.3345	12.1636	18.3844	13.7823	13.1131	10.9234	15.399	12.2649	12.8852
1962	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	16	15.2491	35.012	47.7443	25.7472	72.9705	112.8243	45.8645	75.8086	65.3884	44.9131	34.5361	65.2981	42.0793	33.3124
1962	17	7.7915	16.4055	21.1688	13.2223	31.512	42.4526	22.9021	34.9745	26.7243	24.5621	20.2734	29.7196	23.3306	24.4289
1962	18	2.7106	4.3811	3.8612	5.4403	5.408	3.6341	7.8758	8.4979	4.1611	10.3636	9.83	7.0731	10.1486	17.2281
1962	19	4.9481	10.4448	14.2223	7.8097	21.3368	30.9191	13.6152	22.5221	18.8559	13.1127	9.9368	18.8846	11.7433	8.4641
1962	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	23	0.0979	0.1431	0.0512	0.3019	0.1552	0.0609	0.336	0.2729	0.0837	0.258	0.1344	0.0548	0.0478	0.0859
1962	24	2.024	1.4292	0.573	3.0553	1.7957	0.5539	3.0031	2.4589	0.725	2.0906	1.1136	0.4385	0.4058	0.7068
1962	25	4.883	9.9887	12.4096	8.6668	18.9608	25.6823	13.9524	20.9334	16.2711	13.6141	10.2679	16.7615	11.3613	9.8472
1962	26	4.9875	11.6578	15.2572	7.9866	20.995	30.331	13.7906	22.2918	18.3777	13.6115	10.4879	20.0204	12.4499	9.942
1962	27	4.613	10.0909	13.3113	7.3662	19.3059	27.507	12.6934	20.4992	16.8997	12.5187	9.6433	17.7599	11.4057	9.124
1962	28	1.9162	3.9286	5.2342	2.9637	7.8149	10.9496	5.0795	8.2837	6.8492	4.9073	3.7185	6.9226	4.3662	3.2112
1962	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(8) Sample of daily precipitation data in August for 1960 -1962

Daily Precipitation Data on Augustus for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	0.0916	0.0694	0.0499	0.1023	0.0386	0.0298	0.0432	0.0194	0.0177	0.0198	0.0277	0.0435	0.0244	0.0239
1960	2	0.4867	0	0	0.0859	0	0	0.0047	0	0	0	0	0	0	0
1960	3	2.7456	1.4734	1.0491	2.1545	0.7968	0.6155	0.8826	0.3915	0.3599	0.3998	0.5612	0.9004	0.496	0.4847
1960	4	0.0916	0.0693	0.0494	0.1023	0.0385	0.0295	0.0431	0.0192	0.0177	0.0197	0.0275	0.0433	0.0243	0.0238
1960	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	7	6.4721	4.9907	2.9983	6.163	2.1821	1.4211	2.2492	0.8802	0.7821	0.9104	1.2241	2.1318	1.0815	1.0629
1960	8	0.1778	0.1047	0.0564	0.182	0.11	0.0333	0.429	0.3417	0.0957	0.3277	0.1716	0.0275	0.0737	0.1316
1960	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	10	0.0308	0.0179	0.009	0.032	0.0196	0.0054	0.0724	0.0552	0.0152	0.0541	0.0279	0.0043	0.0116	0.0209
1960	11	0.218	0.1279	0.068	0.2232	0.1343	0.0404	0.5249	0.4159	0.1169	0.4	0.21	0.0333	0.0903	0.1616
1960	12	0.0916	0.0687	0.0475	0.1023	0.0382	0.0287	0.0427	0.0188	0.0175	0.0193	0.0273	0.0423	0.0242	0.0238
1960	13	1.0318	0.9856	0.7161	1.7284	1.1697	0.6732	1.8899	2.0464	1.4616	2.3982	2.3093	1.4208	2.2938	2.8747
1960	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	15	0.0798	0.0465	0.0244	0.0816	0.0489	0.0146	0.19	0.1499	0.0426	0.1448	0.0767	0.0121	0.0332	0.0594
1960	16	1.5989	0.9487	0.6209	1.4775	0.5378	0.3709	0.5732	0.2414	0.2227	0.2511	0.3535	0.5408	0.3074	0.3049
1960	17	3.4239	0.5946	0.3881	1.3405	0.3387	0.233	0.3839	0.1524	0.1408	0.1588	0.2237	0.3396	0.1945	0.1932
1960	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	20	0.0543	0.0313	0.0162	0.0556	0.0331	0.0097	0.1286	0.1006	0.0289	0.098	0.0523	0.0081	0.0227	0.0408
1960	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	22	1.2464	0.932	0.619	1.4101	0.512	0.3746	0.5687	0.2443	0.2327	0.2546	0.3671	0.5549	0.3261	0.324
1960	23	0.1791	0.1332	0.0884	0.2016	0.0742	0.0541	0.0827	0.0357	0.0341	0.0373	0.0537	0.0799	0.0477	0.0475
1960	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	26	0.028	0.0159	0.0081	0.0287	0.017	0.0049	0.0659	0.0512	0.0149	0.0504	0.0272	0.0041	0.0119	0.0214
1960	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	28	0.0916	0.0662	0.0434	0.103	0.0376	0.0269	0.0422	0.0181	0.0174	0.0191	0.0277	0.0401	0.0246	0.0246
1960	29	0.0808	0.0455	0.0229	0.083	0.0488	0.014	0.1907	0.1475	0.043	0.1458	0.0789	0.0117	0.0346	0.0622
1960	30	0.0917	0.0658	0.043	0.1031	0.0376	0.0268	0.0422	0.0181	0.0174	0.0191	0.0278	0.0399	0.0248	0.0248
1960	31	0.3791	0.2919	0.2263	0.47	0.2497	0.3008	0.2801	0.2189	0.3249	0.1655	0.2827	0.2947	0.288	0.2432
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	9	0.2308	0.2136	0.0911	0.3862	0.2422	0.0983	0.5172	0.4215	0.1287	0.445	0.2489	0.084	0.0696	0.1663
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	0.0334	0.0146	0.0092	0.0148	0.021	0.0093	0.043	0.0363	0.0114	0.0481	0.0297	0.0069	0.0059	0.021
1961	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0.3402	0.3756	0.1427	0.7433	0.4077	0.1589	0.8892	0.7059	0.2176	0.7116	0.392	0.1408	0.1206	0.2607
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	0.0333	0.0144	0.0088	0.0148	0.0207	0.009	0.0427	0.0356	0.0113	0.0477	0.0298	0.0067	0.0059	0.0214
1961	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	6	3.6182	8.1421	10.3567	5.9149	15.5083	21.1002	10.4068	16.3256	13.1021	10.011	7.5383	13.9068	9.0952	7.6722
1962	7	13.8643	18.9901	22.4004	16.4178	35.8731	45.3484	24.452	36.2312	28.1903	21.7817	16.1779	28.8538	18.8287	16.1379
1962	8	8.9313	4.4469	3.9132	7.3753	7.4632	3.8668	7.3765	8.6939	7.3328	7.2056	7.0297	4.9984	8.4436	7.2334
1962	9	1.3263	2.0593	1.717	3.5326	3.0557	2.057	5.1068	5.4136	4.0228	5.399	4.51	2.7466	4.4984	4.3465
1962	10	6.2669	13.3453	16.8801	9.2188	24.2836	33.6216	15.9827	24.8708	20.348	15.2333	11.4809	22.499	13.9725	11.5909
1962	11	12.8262	28.8446	36.0555	20.2771	54.0479	78.1515	35.1354	55.0746	45.9363	33.4473	24.8382	49.7876	30.9165	25.0517
1962	12	26.2603	8.6224	4.3954	16.1598	12.1487	2.5152	10.557	9.0305	2.6468	5.5215	3.6201	1.7191	1.6307	2.9113
1962	13	5.577	2.7961	2.007	2.2827	2.5017	1.0051	2.9679	3.1298	1.15	2.8278	1.8936	1.0982	0.7745	1.7617
1962	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	15	4.7771	10.7411	13.2402	7.844	20.4591	27.8807	13.7255	21.3018	17.5133	13.0974	9.9503	18.1946	12.1164	10.228
1962	16	3.9862	8.8607	10.8602	6.5148	16.8221	22.7222	11.3621	17.5546	14.3864	10.8613	8.2796	14.9505	10.0382	8.5222
1962	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	18	2.0133	4.3367	5.2475	3.2466	8.1607	10.7645	5.6128	8.5752	6.9574	5.3952	4.1479	7.2435	4.9666	4.2816
1962	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	21	4.4122	9.7321	11.7317	7.2226	18.57	25.0018	12.5736	19.2832	15.9898	12.0082	9.2206	16.3808	11.2091	9.5462
1962	22	6.128	13.7333	16.5677	10.1209	26.4202	36.08	17.7005	27.2516	22.8782	16.8414	12.9052	23.2397	15.8328	13.372
1962	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	24	4.8183	10.5876	12.6593	7.9024	20.3143	27.3221	13.757	21.0264	17.5679	13.1395	10.1293	17.8227	12.3444	10.5247
1962	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	29	4.4422	9.583	11.3135	7.2693	18.5214	24.6092	12.6256	19.157	16.0823	12.1077	9.41	16.0991	11.4571	9.8408
1962	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont’)

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(9) Sample of daily precipitation data in September for 1960 -1962

Daily Precipitation Data on September for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	0.6041	0.3876	0.232	0.6458	0.2898	0.1425	0.752	0.5331	0.2	0.5309	0.3511	0.185	0.2012	0.2889
1960	2	0.5176	0.1528	0.0872	0.3071	0.1227	0.0537	0.3199	0.22	0.0789	0.2229	0.1419	0.0678	0.0774	0.1139
1960	3	0.952	0.6175	0.4405	1.1546	0.7373	0.4373	1.2393	1.3303	1.0123	1.5599	1.5964	0.923	1.644	2.0731
1960	4	0.1297	0.0711	0.0357	0.1318	0.0774	0.022	0.305	0.2355	0.0692	0.2329	0.1274	0.0184	0.0564	0.1014
1960	5	0.0277	0.0152	0.0076	0.0281	0.0166	0.0047	0.0648	0.0501	0.0148	0.0496	0.0272	0.0039	0.0121	0.0217
1960	6	0.9626	0.6131	0.3162	0.8404	0.3405	0.1561	0.7145	0.4286	0.1736	0.441	0.3006	0.2171	0.1882	0.2526
1960	7	0.4899	0.3321	0.2086	0.5396	0.2089	0.1274	0.3628	0.2192	0.1165	0.2224	0.1964	0.182	0.1418	0.1693
1960	8	0.0648	0.0476	0.0297	0.0766	0.028	0.0182	0.0299	0.0123	0.0118	0.0132	0.0193	0.027	0.017	0.0171
1960	9	0.2977	0.2127	0.1373	0.3389	0.1194	0.0836	0.1323	0.0558	0.0547	0.0592	0.0876	0.1251	0.0791	0.0792
1960	10	1.8875	1.3498	0.8689	2.1621	0.7494	0.5238	0.8277	0.347	0.3402	0.3681	0.5464	0.7866	0.494	0.4942
1960	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	12	0.252	0.1539	0.09	0.2659	0.1252	0.0558	0.3529	0.259	0.0925	0.2576	0.1634	0.0698	0.0908	0.1356
1960	13	0.0544	0.0294	0.0148	0.0554	0.0325	0.0091	0.1275	0.0993	0.0293	0.0979	0.0538	0.0076	0.0243	0.0434
1960	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	19	0.0798	0.0428	0.0215	0.0813	0.0475	0.0132	0.1874	0.1471	0.0431	0.1436	0.0786	0.0111	0.0361	0.0639
1960	20	0.0306	0.0162	0.0077	0.0315	0.0187	0.0047	0.0706	0.0533	0.0152	0.0529	0.0284	0.0039	0.0126	0.0225
1960	21	0.3619	0.0162	0.0077	0.0946	0.0187	0.0047	0.0736	0.0533	0.0152	0.0527	0.0283	0.0039	0.0126	0.0225
1960	22	1.3055	0.755	0.4894	1.4625	0.9307	0.4546	1.9659	1.8997	1.1476	2.1037	1.85	0.8758	1.7418	2.2736
1960	23	0.3599	0.3566	0.2232	0.5003	0.5443	0.2879	0.5212	0.4874	0.3109	0.3082	0.2612	0.234	0.3056	0.2236
1960	24	3.4024	2.7903	1.9089	5.0735	2.9454	1.6977	5.1049	5.2982	3.9145	6.1178	6.2799	3.495	6.5268	8.3497
1960	25	0.1046	0.0561	0.0281	0.1066	0.0618	0.0169	0.246	0.1947	0.0561	0.1872	0.1018	0.0144	0.0473	0.0835
1960	26	2.6987	2.3238	1.6289	4.3214	2.8757	1.6175	4.9627	5.56	4.1867	6.425	6.6313	3.5086	7.1616	9.171
1960	27	0.3858	0.287	0.1756	0.4672	0.1672	0.1026	0.1943	0.0794	0.0696	0.0816	0.1141	0.1534	0.1009	0.1027
1960	28	1.1768	0.8185	0.5169	1.3353	0.4758	0.3036	0.6661	0.3543	0.2391	0.3521	0.3878	0.4565	0.327	0.3518
1960	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	7	0.1673	0.0642	0.0361	0.0681	0.0934	0.0366	0.1987	0.1588	0.0483	0.2162	0.1318	0.0262	0.0256	0.0931
1961	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	0.0441	0.0169	0.0095	0.018	0.0249	0.0097	0.0523	0.042	0.0129	0.0575	0.0352	0.0069	0.0068	0.025
1961	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	16	0.168	0.0637	0.0359	0.0684	0.0937	0.0362	0.1996	0.1613	0.0489	0.2179	0.1327	0.0259	0.0263	0.0949
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0.0442	0.0168	0.0094	0.018	0.0248	0.0095	0.0524	0.0426	0.0129	0.0575	0.035	0.0068	0.0069	0.0252
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	25	0.0867	0.0328	0.0184	0.0353	0.0478	0.0182	0.1028	0.0843	0.0251	0.1113	0.0674	0.0132	0.0136	0.0488
1961	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(10) Sample of daily precipitation data in October for 1960 -1962

Daily Precipitation Data on October for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	2.317	1.633	1.0284	2.8294	0.9735	0.6278	1.421	0.779	0.5712	0.8378	1.0637	1.1458	1.0242	1.2077
1960	2	0.0937	0.0156	0.008	0.0455	0.0177	0.005	0.077	0.0662	0.0212	0.0649	0.0417	0.0049	0.0208	0.0404
1960	3	0.4822	0.359	0.2279	0.604	0.2039	0.1394	0.2393	0.1059	0.1096	0.1182	0.1987	0.2588	0.2156	0.2358
1960	4	0.3431	0.1853	0.0903	0.3914	0.2187	0.0561	0.9388	0.7761	0.2366	0.7756	0.4877	0.0536	0.2284	0.4513
1960	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	6	0.1217	0.1141	0.0535	0.1807	0.1071	0.0341	0.1741	0.1336	0.0833	0.1468	0.1587	0.0929	0.2124	0.2309
1960	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	11	0.0277	0.0152	0.0076	0.0308	0.0165	0.0046	0.0737	0.0638	0.0196	0.061	0.0389	0.0046	0.0196	0.0379
1960	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	15	0.0536	0.0293	0.0145	0.0596	0.0312	0.0087	0.1425	0.1225	0.0369	0.1163	0.0738	0.0088	0.0373	0.0721
1960	16	1.6609	1.1968	0.5829	2.0803	1.1257	0.3667	3.2645	2.6954	1.0531	2.6674	2.0654	0.7214	1.7896	2.4347
1960	17	2.5776	1.3649	0.7429	2.6112	1.0567	0.4402	3.4519	2.6358	0.9052	2.5945	1.8439	0.713	1.1294	1.8266
1960	18	0.1513	0.0304	0.024	0.0919	0.0498	0.0405	0.1633	0.22	0.1192	0.1662	0.1428	0.0302	0.1246	0.1605
1960	19	1.418	0.3507	0.1692	0.8648	0.361	0.103	1.569	1.2808	0.3746	1.2466	0.778	0.1248	0.3889	0.7347
1960	20	0.2112	0.1145	0.0524	0.2402	0.1243	0.0309	0.566	0.4584	0.1307	0.4445	0.2763	0.0312	0.1312	0.2586
1960	21	0.8074	0.5361	0.4187	1.1453	0.8686	0.706	2.9756	4.0777	2.1757	3.0532	2.6437	0.5271	2.2983	2.998
1960	22	0.7939	0.592	0.4469	0.756	0.6017	0.5055	1.7913	1.9445	1.0716	1.4335	1.2495	0.5111	1.1301	1.4086
1960	23	0.1707	0.0164	0.0074	0.0655	0.0175	0.0043	0.0807	0.0638	0.0181	0.0617	0.0385	0.0044	0.0184	0.0362
1960	24	0.1408	0	0	0.0314	0	0	0.0015	0	0	0	0	0	0	0
1960	25	0.7801	0.5328	0.3037	0.918	0.3219	0.1747	0.8289	0.5866	0.2492	0.571	0.4895	0.3238	0.3805	0.5295
1960	26	0.5177	0.2836	0.1331	0.5757	0.284	0.0766	1.3852	1.144	0.3279	1.0869	0.6827	0.0804	0.3394	0.6648
1960	27	0.2604	0.1918	0.1136	0.3151	0.0935	0.0646	0.1255	0.0534	0.0513	0.0573	0.0964	0.1313	0.1091	0.1173
1960	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	29	1.0058	0.7171	0.4126	1.2011	0.3805	0.2328	0.753	0.4525	0.2482	0.4534	0.485	0.4592	0.4455	0.5502
1960	30	0.6092	0.4546	0.2582	0.7503	0.227	0.1448	0.294	0.1202	0.1127	0.1307	0.2182	0.2938	0.2409	0.2598
1960	31	0.6217	0.3382	0.148	0.7037	0.3472	0.0839	1.6594	1.2798	0.353	1.2571	0.7793	0.0872	0.3632	0.7234
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0.5154	0.3447	0.2558	0.1613	0.1909	0.098	0.1311	0.2076	0.0793	0.0839	0.0666	0.1278	0.045	0.0842
1961	5	0.2138	0.2973	0.0917	0.6945	0.3143	0.1099	0.7332	0.5708	0.1706	0.5388	0.2782	0.104	0.1058	0.1903
1961	6	1.3188	0.4231	0.1858	0.9564	0.66	0.1222	0.6445	0.5415	0.1537	0.3279	0.2053	0.071	0.0935	0.1461
1961	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	8	0.6568	0.4385	0.3213	0.2047	0.2384	0.1213	0.1658	0.2629	0.0987	0.1049	0.0829	0.1602	0.0563	0.1052
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	15	0.3291	0.2194	0.1563	0.1025	0.1156	0.0578	0.0824	0.1299	0.0473	0.0511	0.0401	0.0781	0.0275	0.051
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0.3431	0.1342	0.0718	0.1465	0.1818	0.0708	0.4335	0.3534	0.0998	0.4609	0.2761	0.0563	0.0603	0.2083
1961	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	27	2.4247	0.7778	0.3099	1.7405	1.0867	0.1891	1.144	0.9093	0.2381	0.5387	0.3322	0.118	0.1535	0.2374
1961	28	5.7858	3.8472	3.4027	6.461	6.1907	3.6251	7.2364	9.1179	8.1943	7.154	7.2731	5.0303	10.3196	7.4884
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0.8496	0.5648	0.3774	0.2582	0.2752	0.1323	0.2034	0.3066	0.1076	0.1209	0.0945	0.1859	0.0657	0.1194
1961	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	7	0.1509	0.102	0.0725	0.0862	0.0549	0.0395	0.0027	0.0167	0.0113	0	0.0019	0.0649	0.0358	0.0176
1962	8	0	0	0	0.027	0	0	0.4251	0.2191	0	0.4787	0.2917	0	0	0.0894
1962	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	12	0.7751	1.5991	1.7597	1.4372	2.8919	3.4676	4.5308	4.5844	2.5191	4.6588	3.179	2.4982	2.0111	2.2421
1962	13	1.1359	2.3609	2.5911	1.893	4.2553	5.124	3.2184	4.9629	3.7066	2.9661	2.2908	3.6819	2.9525	2.5484
1962	14	0	0	0	0.0175	0	0	0.2734	0.1397	0	0.3015	0.1829	0	0	0.0566
1962	15	2.7724	5.2943	5.9112	4.9955	9.6196	10.4704	8.3048	12.6418	10.3575	8.5237	7.6547	8.9594	10.5391	8.798
1962	16	0	0	0	0.0071	0	0	0.1097	0.0558	0	0.12	0.0727	0	0	0.0226
1962	17	3.7921	1.2073	0.5036	2.6574	1.7875	0.3278	1.9007	1.6096	0.4494	1.0108	0.6765	0.2137	0.3065	0.5968
1962	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	19	1.016	0.3324	0.1374	0.7358	0.4819	0.0865	0.4958	0.419	0.1174	0.24	0.1616	0.0562	0.082	0.1422
1962	20	0.3961	0.1931	0.1143	0.4217	0.4229	0.1393	0.777	0.8298	0.3128	0.8039	0.5522	0.1492	0.2693	0.5382
1962	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	22	2.3877	3.5007	3.4198	2.8115	5.0921	5.9079	3.9608	5.8375	4.1323	3.573	2.7202	4.6402	3.5793	3.0127
1962	23	2.9094	5.1919	5.117	4.4962	7.9829	9.1857	6.9437	9.6096	6.5921	6.0659	4.4886	7.1023	5.4023	4.8266
1962	24	9.7885	7.4044	6.2662	8.4403	11.2063	10.1963	9.4702	11.8936	7.4647	7.2471	5.3343	7.7201	6.0617	5.5711
1962	25	17.034	6.6518	2.5058	13.2114	7.7333	1.563	10.3432	8.0161	2.1271	5.9619	3.6085	1.3186	1.5496	3.0448
1962	26	17.0637	19.0018	15.3717	21.3798	26.3656	26.1636	25.241	31.115	19.1653	19.9617	14.2222	20.1503	15.6707	14.9913
1962	27	15.2064	17.4509	13.1191	25.1761	22.7225	17.4225	29.8505	32.941	22.3441	26.4949	21.7856	18.9406	25.8012	23.3421
1962	28	3.4603	1.8091	0.6944	3.2253	1.9992	0.5742	4.0078	3.1263	0.8946	3.1447	1.9349	0.5438	0.6564	1.6882
1962	29	15.4616	11.3588	8.7845	17.2884	16.9287	11.9466	18.9935	22.0249	14.8718	16.0181	14.0186	12.0943	16.9457	15.3047
[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(11) Sample of daily precipitation data in November for 1960 -1962

Daily Precipitation Data on November for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	6.9842	0.7097	0.2577	1.7635	0.4579	0.1101	1.7964	1.1194	0.3098	1.1724	0.6823	0.1637	0.3511	0.6511
1960	2	1.1608	0.7026	0.3493	1.2825	0.5376	0.1922	2.202	1.6846	0.5199	1.6567	1.1069	0.2989	0.6304	1.1086
1960	3	0.0946	0.0668	0.0374	0.1145	0.0316	0.0198	0.042	0.0166	0.0153	0.0187	0.0304	0.0417	0.0344	0.0369
1960	4	0.7809	0.5856	0.3311	0.9499	0.2685	0.174	0.3928	0.1531	0.137	0.1674	0.2771	0.3676	0.3076	0.3374
1960	5	1.2526	1.4576	1.0085	2.4721	2.5011	1.7384	4.0948	4.8664	2.7753	3.1658	3.0747	1.4018	3.2867	3.4841
1960	6	6.6005	2.3215	1.7375	3.4662	2.1501	1.8398	7.5228	8.4085	4.1821	6.1974	4.7456	1.9073	4.8367	5.9495
1960	7	0.1888	0.1438	0.077	0.2417	0.0701	0.0399	0.0873	0.0329	0.0298	0.0379	0.0613	0.0827	0.0672	0.0722
1960	8	0.6625	0.4997	0.2776	0.8229	0.2299	0.143	0.3015	0.1156	0.1077	0.132	0.2174	0.3016	0.2455	0.2623
1960	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	10	3.5445	2.157	0.8272	3.0468	1.2758	0.3534	3.6372	2.1454	0.7506	2.3617	1.6806	0.7299	1.2971	1.8396
1960	11	7.2011	0.5861	0.2466	1.5561	0.272	0.1001	0.6624	0.3276	0.1275	0.357	0.2769	0.1976	0.2032	0.2875
1960	12	8.167	2.9138	1.9699	4.3338	3.3979	1.9959	6.581	6.758	3.2529	6.0271	3.9796	2.0077	3.5174	4.1322
1960	13	1.5396	0.9932	0.6913	1.9443	1.4874	1.0946	5.316	6.0515	3.2045	4.642	4.5057	0.8351	3.4173	4.5986
1960	14	2.618	0.684	0.3793	1.479	0.3108	0.1916	0.419	0.1486	0.1418	0.1739	0.2891	0.4028	0.3243	0.3459
1960	15	0.7464	0.0472	0.0327	0.2945	0.0808	0.0552	0.2423	0.2709	0.1444	0.2249	0.2053	0.0403	0.1512	0.1972
1960	16	3.8912	2.4273	0.9713	3.2732	1.1909	0.3843	3.243	1.7456	0.6013	1.9372	1.3443	0.7165	0.8565	1.3328
1960	17	1.9739	0.9808	0.4103	1.9738	0.9362	0.213	4.4837	3.0756	0.8667	3.2602	2.0419	0.2218	0.9073	1.8522
1960	18	13.4748	10.8106	8.3904	13.9844	8.085	8.2822	17.229	17.0745	11.7389	14.2943	12.2495	9.6414	13.2871	14.3816
1960	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	20	2.5158	1.412	0.4064	1.9765	0.8755	0.1494	3.653	2.0619	0.5602	2.3069	1.3157	0.159	0.5739	1.1877
1960	21	1.4109	1.6685	1.1155	2.7012	2.8245	1.8448	4.8418	5.2008	3.064	3.7662	3.8237	1.4509	3.4705	3.8921
1960	22	3.8397	3.0957	2.3576	4.0948	2.0294	2.3758	2.3114	1.6009	2.2266	1.4178	2.1005	2.909	2.3824	2.1481
1960	23	0.1334	0.0736	0.03	0.1528	0.0719	0.015	0.3055	0.2024	0.0581	0.2327	0.1395	0.0151	0.0599	0.1215
1960	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	25	7.6842	6.2982	4.5165	10.424	6.2053	6.0905	13.0269	12.6154	9.6016	10.2107	11.9782	5.8461	9.9744	11.7141
1960	26	0.6374	0.6065	0.2491	0.8837	0.4709	0.1283	0.7829	0.4834	0.2945	0.6122	0.6694	0.3878	0.8358	0.9076
1960	27	2.3068	1.1561	0.3608	1.7087	0.7311	0.1363	2.4326	1.2999	0.3732	1.6362	0.8822	0.1858	0.4038	0.7733
1960	28	2.8677	0.7173	0.508	1.1792	0.5558	0.5105	0.5003	0.3218	0.4427	0.3037	0.435	0.6002	0.4573	0.4105
1960	29	14.2045	8.0324	5.8399	10.2986	6.2466	5.8079	11.2268	9.3316	7.4052	7.7694	8.3343	6.5382	7.758	8.5831
1960	30	6.2443	1.7796	0.4132	3.053	1.0264	0.1375	3.5343	1.787	0.4909	2.2784	1.1907	0.1393	0.4831	1.0116
1961	1	1.07	1.4731	1.63	1.947	2.4353	1.8184	3.1976	4.3342	4.1273	3.7328	3.795	2.682	5.3323	3.9427
1961	2	10.1063	3.255	1.3088	6.5469	4.1658	0.7458	4.3933	3.4034	0.901	2.1766	1.3658	0.4847	0.6013	1.0095
1961	3	9.0556	3.4296	1.6063	6.5696	4.314	1.0543	4.8502	4.0603	1.3171	3.0883	2.5126	1.377	2.1636	3.4357
1961	4	0.1262	0.0484	0.0255	0.0468	0.057	0.0226	0.1338	0.1045	0.0302	0.1372	0.0853	0.0192	0.0198	0.067
1961	5	13.3755	6.0422	2.0828	12.8462	6.8847	1.441	10.4639	7.6716	1.9689	5.841	3.289	1.1566	1.2847	2.2998
1961	6	4.6408	3.9695	1.1877	8.5166	3.7518	1.0473	8.1561	5.7982	1.5509	5.0454	2.672	1.0259	1.0468	1.8585
1961	7	7.2369	4.7395	1.9157	9.0229	4.9465	1.5441	8.964	6.8599	2.1151	6.4801	4.422	2.0982	2.9638	5.1133
1961	8	1.0128	1.8296	2.1079	2.2982	2.9226	2.3121	3.6468	5.0528	5.3116	4.2994	4.7149	3.5142	7.0621	4.9664
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	11	4.2771	1.4445	0.6325	2.2136	1.6008	0.3684	2.1428	1.5747	0.4398	1.4616	0.9137	0.2752	0.2942	0.6933
1961	12	4.1031	1.3747	0.554	2.5559	1.6079	0.2842	1.6192	1.1722	0.3221	0.7384	0.465	0.1886	0.2249	0.3402
1961	13	1.696	1.2795	0.8852	1.5507	1.498	0.7496	2.6213	2.4536	1.0519	2.9158	2.4852	1.4229	2.2299	3.6741
1961	14	12.8666	4.1426	1.6454	8.1912	5.2545	0.9269	5.6984	4.1659	1.1116	2.8199	1.8035	0.605	0.7381	1.2984
1961	15	0.3253	0.1276	0.0669	0.1208	0.1487	0.0581	0.3533	0.2617	0.0773	0.3554	0.2258	0.0487	0.05	0.1733
1961	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	22	0.4828	0.1927	0.1021	0.1768	0.2234	0.0872	0.5144	0.3688	0.1131	0.515	0.3318	0.0718	0.0725	0.2517
1961	23	0.1343	0.0539	0.0287	0.0493	0.0625	0.0244	0.1427	0.102	0.0315	0.1426	0.0922	0.0201	0.0202	0.07
1961	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	25	0.3376	0.1361	0.0726	0.1232	0.1576	0.0615	0.3567	0.2528	0.079	0.3564	0.2312	0.0503	0.0504	0.1747
1961	26	5.9212	2.0354	0.8305	3.7834	2.4774	0.436	2.3795	1.6491	0.4814	1.0596	0.7004	0.2749	0.3291	0.501
1961	27	0.1221	0.0433	0.0235	0.0347	0.0446	0.0176	0.0956	0.0661	0.0212	0.0941	0.0607	0.0148	0.0137	0.0465
1961	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	0.0473	0.0194	0.0105	0.0172	0.0227	0.0088	0.0492	0.0343	0.0111	0.0494	0.0325	0.0071	0.007	0.0244
1962	1	6.131	8.6224	7.1073	14.3846	11.9369	7.8203	18.8177	21.686	18.8939	19.9114	19.459	12.8057	26.2411	21.4439
1962	2	14.3372	17.9605	14.4295	18.3487	22.7767	23.1897	23.6879	27.3026	16.6206	19.2539	13.1966	18.7884	13.9361	13.4711
1962	3	2.2514	3.5527	3.0987	3.5102	5.1391	5.4618	5.5902	6.6299	4.0782	4.8459	3.4803	4.3036	3.4791	3.5783
1962	4	5.7822	2.4004	0.8973	5.0354	2.9464	0.6419	4.205	3.2238	0.9097	2.6481	1.6553	0.5446	0.7143	1.4166
1962	5	8.5364	3.3624	1.4696	5.6171	3.5812	0.8219	4.4606	3.481	0.9958	2.806	1.7526	0.7967	0.8316	1.5577
1962	6	8.8584	8.6525	8.1743	10.1894	13.1165	10.5246	15.2526	19.165	15.7821	15.9979	15.548	12.5839	20.2478	17.5926
1962	7	2.2598	4.818	4.8869	3.5875	7.5194	8.9507	6.0265	8.5452	6.1779	5.2326	4.054	6.864	5.362	4.4745
1962	8	1.8408	1.3147	0.448	2.6458	1.2528	0.3527	2.3033	1.7028	0.4911	1.4267	0.8402	0.3831	0.4033	0.7339
1962	9	0.6324	0.5734	0.2664	0.8482	0.3697	0.1705	1.0858	0.6936	0.1518	0.9064	0.5442	0.2555	0.1881	0.3383
1962	10	7.08	4.8325	3.7063	5.8621	6.8356	5.379	6.6751	7.3142	4.1725	5.2215	3.8071	4.369	3.6746	3.8367
1962	11	15.8681	6.0624	2.201	12.8073	7.306	1.4048	11.4999	7.889	1.8704	7.1128	4.4541	1.1301	1.394	3.1011
1962	12	7.7695	4.066	1.3936	8.4176	4.3917	1.0307	8.7887	5.9454	1.4613	5.9714	3.6317	0.9522	1.1049	2.5879
1962	13	0.3551	0.2373	0.1521	0.2009	0.1049	0.0719	0.3297	0.1782	0.0192	0.3385	0.2142	0.1303	0.0696	0.0996
1962	14	0	0	0	0.0024	0	0	0.0366	0.0168	0	0.0384	0.024	0	0	0.0077
1962	15	0	0	0	0.0116	0	0	0.1722	0.0784	0	0.1789	0.1119	0	0	0.0357
1962	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	19	8.0255	2.6266	1.0329	5.2887	3.3749	0.5757	3.3794	2.4655	0.7073	1.5177	1.0562	0.3894	0.5317	0.9046
1962	20	0.9556	0.3386	0.1396	0.6105	0.3886	0.0715	0.3964	0.2776	0.0815	0.1843	0.126	0.0512	0.0649	0.1066
1962	21	3.0679	1.2079	0.5704	1.7819	1.1387	0.2653	1.1062	0.7848	0.2291	0.5557	0.3462	0.2804	0.2353	0.3126
1962	22	2.2794	1.4209	0.8971	1.0794	0.762	0.4525	0.7775	0.6177	0.2141	0.7766	0.5388	0.7265	0.4244	0.5394
1962	23	0.1623	0.0599	0.0321	0.0507	0.0644	0.0253	0.1454	0.1023	0.0327	0.1481	0.1014	0.0226	0.024	0.0905
1962	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	25	6.6521	3.2712	1.1742	6.3165	3.5898	0.8	5.2183	3.5971	1.0744	3.0483	1.9426	0.6952	0.8039	1.6339
1962	26	4.3462	5.9947	5.9543	5.6366	8.5889	8.0485	7.9574	9.6905	8.5965	7.7749	7.5608	8.1092	10.1108	8.2068
1962	27	4.9895	10.507	11.3949	8.9305	15.8298	16.0547	14.6482	18.9131	17.945	15.2522	15.3571	16.4701	21.412	17.0537
1962	28	24.0355	10.2983	5.7145	17.9262	12.9144	4.1602	13.2976	11.4352	7.3912	8.9095	8.3452	5.3222	9.2576	8.7323
1962	29	13.116	18.0333	10.3968	24.4629	18.5593	13.85	27.0956	21.6981	11.1849	18.8685	12.3977	11.7426	9.0904	11.1238
1962	30	8.1253	4.5802	2.0588	6.9823	3.9751	1.1481	4.645	3.2812	1.0669	2.5664	1.6552	1.3571	1.0819	1.5323

Appendix C : Daily Precipitation Data for 1996 – 2006 in Banyuwangi Regency (Cont')

Appendix C presents only sample data of the daily precipitation of each month from 1960 to 1962. The remaining data of the years 1993 – 2006 are not presented in this Appendix.

(12) Sample of daily precipitation data in December for 1960 -1962

Daily Precipitation Data on December for 1960 - 2006 in Banyuwangi Regency

	Coordinate	St-1	St-2	St-3	St-4	St-5	St-6	St-7	St-8	St-9	St-10	St-11	St-12	St-13	St-14
	LA	113.625	114.125	114.375	113.875	114.125	114.375	113.875	114.125	114.375	114.125	114.375	114.625	114.625	114.625
	LO	-7.875	-7.875	-7.875	-8.125	-8.125	-8.125	-8.375	-8.375	-8.375	-8.625	-8.625	-8.125	-8.375	-8.625
Year	Day														
1960	1	2.1672	1.4446	0.7291	2.2089	1.0756	0.3789	3.3458	2.0847	0.6959	2.1501	1.3679	0.498	0.7188	1.1078
1960	2	0.9052	0.672	0.3901	0.9466	0.3475	0.1991	0.5941	0.2999	0.1749	0.3136	0.3134	0.3211	0.2458	0.2785
1960	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	5	4.3257	0.1423	0.0721	0.6267	0.057	0.0288	0.0861	0.0184	0.0175	0.0213	0.0305	0.0485	0.0282	0.0277
1960	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	7	0.2161	0.1296	0.0437	0.1639	0.0779	0.0155	0.2709	0.1542	0.0442	0.17	0.0876	0.0143	0.0386	0.0693
1960	8	1.4035	0	0	0.2659	0	0	0.0129	0	0	0	0	0	0	0
1960	9	3.08	0	0	0.3313	0	0	0.0189	0	0	0	0	0	0	0
1960	10	3.6397	2.5946	1.2861	3.0145	1.2646	0.5173	2.9132	1.5439	0.6259	1.6306	1.1516	0.7783	0.7151	0.9789
1960	11	0.1983	0.1364	0.0765	0.1951	0.0887	0.0389	0.2356	0.1464	0.0585	0.1507	0.1081	0.055	0.0638	0.0912
1960	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	13	1.3576	0.6574	0.3091	0.96	0.5678	0.1638	1.2269	0.7613	0.3222	0.7923	0.568	0.2707	0.4352	0.4865
1960	14	0.9191	2.187	1.0866	2.6827	1.664	0.5698	2.2541	1.3027	0.8108	1.3465	1.2834	1.1035	1.4204	1.2087
1960	15	0.1971	0.2049	0.0874	0.2124	0.145	0.0373	0.1867	0.105	0.0599	0.1098	0.0955	0.0801	0.1069	0.0886
1960	16	1.7884	1.1362	0.5547	1.7857	0.9635	0.2756	2.996	1.8346	0.5908	2.0292	1.1761	0.3188	0.5448	0.9036
1960	17	6.3687	7.2239	6.7766	8.4842	8.7599	7.8222	9.7166	10.0765	8.1153	8.8726	8.2578	8.2754	9.1618	9.4953
1960	18	1.1753	0.9335	0.685	1.0552	0.5915	0.5534	0.8635	0.609	0.6093	0.5056	0.5768	0.6513	0.585	0.5389
1960	19	5.0609	1.6741	0.799	2.1494	1.0124	0.3413	1.218	0.5985	0.3847	0.6355	0.6206	0.6341	0.6478	0.5699
1960	20	11.0208	7.471	3.4857	9.0042	3.9067	1.5161	4.3742	2.3981	1.8694	2.9882	3.231	2.9606	3.1998	3.6633
1960	21	0.9727	0.3334	0.1799	0.5172	0.2186	0.09	0.2933	0.142	0.0949	0.1509	0.1578	0.1582	0.1541	0.1416
1960	22	5.9784	5.4403	2.9147	7.235	4.1287	1.7738	6.2146	4.8514	3.8352	6.4105	6.7519	4.1804	6.8305	8.7941
1960	23	6.1026	8.7138	7.2935	9.6536	10.1618	7.6266	11.2791	10.7704	8.1781	10.0833	8.8144	7.8963	8.4639	9.0476
1960	24	17.7275	17.9661	11.4137	19.2964	20.1964	10.3212	20.0571	15.6693	10.5213	12.9498	10.5789	10.1325	10.5145	9.541
1960	25	5.2419	3.3772	3.0712	4.0242	4.5933	3.6178	5.4542	5.7093	4.0532	4.8054	4.4302	3.6357	4.4613	5.0195
1960	26	7.4166	5.7449	3.5969	7.4546	2.6427	1.6992	3.088	1.1529	1.0945	1.2845	1.8681	2.8242	1.6487	1.6899
1960	27	8.8743	6.4873	3.352	7.7146	3.7359	1.6078	6.4652	3.9804	2.5873	4.7832	4.5889	3.1818	4.0487	5.3309
1960	28	1.6767	0	0	0.1714	0	0	0.0137	0	0	0	0	0	0	0
1960	29	5.2628	4.1735	1.9101	4.7089	1.7547	0.6943	1.6954	0.5654	0.4243	0.6697	0.7572	1.125	0.6067	0.652
1960	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	31	0.1545	0.11	0.077	0.164	0.1403	0.0876	0.4057	0.368	0.218	0.3103	0.282	0.067	0.1929	0.2458
1961	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	7	1.4931	1.7797	0.6036	2.8864	1.4467	0.4957	3.1974	2.097	0.7229	2.2336	1.3119	0.5296	0.514	0.947
1961	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	10	4.1667	3.2732	2.3489	4.9679	4.0591	2.0536	5.0732	4.62	4.0239	4.1636	4.0176	2.7278	4.7255	3.7908
1961	11	1.9558	2.7696	2.8306	2.8552	3.6399	2.6005	4.6709	4.9635	5.014	5.4532	5.9382	4.2123	7.3038	7.2191
1961	12	4.5742	4.9449	2.7157	7.3105	4.6908	2.1969	7.4659	5.7492	3.9138	5.5863	4.5036	2.8959	4.336	4.0587
1961	13	2.0134	1.1937	0.5512	1.418	1.1923	0.4529	2.5171	1.6504	0.5636	2.234	1.4335	0.3919	0.3585	1.0534
1961	14	8.2492	6.4186	2.1558	11.6044	5.936	1.5437	10.1427	6.3476	2.0258	5.99	3.464	1.4101	1.3213	2.3433
1961	15	1.9729	1.0719	0.5233	1.1948	1.1263	0.4316	2.4235	1.6055	0.547	2.2117	1.4519	0.3647	0.3373	1.0644
1961	16	16.4464	5.7727	2.5098	9.1835	6.4152	1.1202	5.5256	3.6057	1.1379	2.3392	1.6012	0.696	0.7342	1.1387
1961	17	20.1145	6.8426	2.9314	12.2062	8.6092	1.5071	7.9494	5.291	1.6368	3.628	2.5012	0.9164	1.0204	1.7431
1961	18	8.8103	5.0128	2.4155	8.0626	5.5241	1.6065	6.9349	4.9819	1.9847	4.8856	3.9032	2.1324	2.8529	4.7603
1961	19	4.2176	4.5144	4.0939	4.5534	5.3172	3.3176	7.2982	6.967	5.5276	8.3266	8.4755	5.8786	9.0843	11.5813
1961	20	15.3671	12.5449	11.1599	11.5705	16.8515	15.5203	12.46	13.0625	10.3527	9.0139	7.0814	11.4996	7.3137	6.0809
1961	21	16.0795	9.4537	3.8481	15.1466	9.0174	2.3032	12.035	7.6672	2.6865	7.2706	4.9419	2.5861	2.9073	4.927
1961	22	7.5325	5.8167	5.0415	5.5063	7.4695	6.5501	5.5264	5.696	4.4062	3.7873	3.0251	4.9588	3.1524	2.6296
1961	23	18.4745	14.869	13.2444	13.8502	19.8513	18.3136	14.1872	14.9412	12.0361	9.9206	7.8615	13.4995	8.4099	6.782
1961	24	14.6106	9.9048	3.6435	15.956	9.033	2.2606	14.0524	9.0011	3.0097	8.3537	5.0122	2.0709	1.9479	3.4751
1961	25	2.4015	4.353	4.6108	5.0484	5.7732	4.3021	7.0379	7.6411	9.0992	7.4362	8.159	6.3016	10.8161	8.0015
1961	26	21.0285	29.6456	31.0683	25.031	42.6131	42.8054	34.1063	39.681	37.2428	30.616	29.8771	37.9534	36.6575	31.9877
1961	27	0.2886	0.2754	0.1195	0.4792	0.331	0.1135	0.6148	0.4672	0.1938	0.5027	0.3331	0.1207	0.1434	0.2535
1961	28	10.1968	8.9136	3.5315	14.3537	8.2639	3.6284	12.8236	8.5479	3.8267	7.6325	4.7682	3.116	2.0838	3.2302
1961	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	30	6.5287	2.6577	1.4246	3.8871	3.1164	0.8978	2.6138	1.8522	0.8444	1.2797	0.907	0.608	0.4956	0.66
1961	31	5.9034	11.9583	14.3041	11.3429	17.871	18.4194	17.657	20.9838	22.5324	18.1011	18.2025	18.7653	23.2204	17.1314
1962	1	28.1012	21.4427	15.4129	26.4168	26.1588	18.274	27.1554	25.5692	17.4491	20.2294	15.8758	16.0732	15.9065	13.9001
1962	2	29.7502	17.7933	10.6036	26.936	20.2465	8.1735	25.9161	21.9695	15.735	20.1176	17.1381	10.5668	17.9611	15.5343
1962	3	32.5726	47.9901	35.4866	57.0635	54.906	43.8919	70.9125	64.881	45.6784	59.9503	48.8814	44.6312	49.5183	50.3592
1962	4	11.7636	23.8889	24.291	20.4092	34.0776	34.8556	33.0944	37.7337	32.5796	32.9666	30.9716	33.2147	37.5019	35.2606
1962	5	0.8902	1.3986	0.6826	2.1991	1.2478	0.5739	3.0093	2.0127	0.7441	2.6552	2.0255	0.9958	1.407	2.4159
1962	6	1.237	2.4269	2.877	2.7282	3.7201	2.906	4.2504	5.2856	6.534	4.9387	5.7306	4.3323	8.2767	5.8237
1962	7	0	0.311	0.2608	0	0	0.0785	0	0	0	0	0	0.1831	0.0121	0
1962	8	1.1258	0.7012	0.471	0.4309	0.2811	0.1878	0.0489	0.0762	0.0455	0.0375	0.0304	0.3122	0.1345	0.0642
1962	9	3.3427	2.0685	1.3931	1.2491	0.8208	0.5498	0.0322	0.1749	0.1317	0	0.0215	0.9143	0.3895	0.1681
1962	10	3.8719	2.6396	1.7101	3.2093	2.7885	1.2071	3.2997	2.7452	1.3655	3.247	3.2381	2.2147	3.2738	5.4374
1962	11	12.5927	5.0784	2.3818	7.5037	5.4909	1.267	5.6343	3.8983	1.3814	3.428	2.5156	1.3018	1.5373	2.5624
1962	12	1.6106	1.7505	0.6695	2.7685	1.4171	0.492	3.0512	1.9343	0.6348	2.083	1.2389	0.5296	0.4186	0.8606
1962	13	8.1003	6.4267	4.9153	8.7411	7.9595	4.0855	9.4438	8.8123	7.1636	9.2755	9.9617	6.8249	11.6533	13.7021
1962	14	1.6212	2.5547	0.7798	4.3503	1.9305	0.6409	4.3271	2.7161	0.9228	2.7253	1.5448	0.6837	0.6009	1.0892
1962	15	34.8736	40.0375	37.0863	33.9602	51.4082	52.1735	40.0079	43.6553	37.0627	30.8928	25.1835	40.3456	28.6779	22.3012
1962	16	31.4443	17.1791	7.6274	28.1606	17.671	4.8735	24.3529	16.3163	7.5242	14.9327	10.529	5.144	6.9291	7.8491
1962	17	36.6004	47.1904	40.8551	43.9156	57.1283	53.2133	52.2033	52.3043	40.8623	42.6355	36.1051	46.4981	38.9446	39.068
1962	18	2.9083	1.739	0.9019	1.8149	1.2973	0.5098	1.9556	1.3268	0.4833	1.5201	0.9747	0.5751	0.3826	0.7703
1962	19	0.8663	0.481	0.235	0.5655	0.4337	0.1675	1.6016	0.8682	0.2013	1.4772	0.9332	0.1582	0.1293	0.4826
1962	20	7.6466	6.4658	5.4321	9.1365	8.5504	4.8217	9.9012	9.7663	10.1349	8.8767	9.377	6.6886	11.8448	9.0524
1962	21	20.0906	17.4675	12.1247	21.1495	20.3941	13.9001	20.8375	18.2082	11.0233	15.8739	13.2777	13.1604	12.282	16.7259
1962	22	25.9703	15.0162	10.4822	20.2913	17.4099	7.4939	18.1792	15.9335	13.3548	15.0794	15.4192	11.0423	17.668	17.7558
1962	23	11.4795	7.642	6.5554	6.6301	7.1845	4.5297	7.9001	7.6698	7.6391	8.1418	7.713	6.4766	9.1419	7.4487
1962	24	18.4302	11.0666	5.2758	13.8102	9.1633	2.9719	13.4199	8.6919	3.0825	9.7493	6.4505	3.6179	3.3826	6.2269
1962	25	4.0879	2.5998	1.1662	3.1158	2.2713	0.849	4.7216	3.0466	1.0647	3.8727	2.4523	0.8065	0.6589	1.8007
1962	26	38.3518	33.9416	32.1764	29.3697	45.0138	40.9019	35.9227	37.7164	31.2466	29.4618	25.9594	34.0487	27.4641	26.1381
1962	27	22.094	27.4963	27.8273	19.8032	36.7546	40.0688	26.7301	30.1108	25.5387	21.9086	18.3613	30.7506	19.9975	19.0492
1962	28	0.7536	0.4404	0.2911	0.2637	0.3674	0.1779	0.7478	0.5032	0.178	0.7384	0.507	0.1906	0.1102	0.3786
1962	29	5.2128	9.8696	11.3742	7.7548	13.9044	14.4723	11.928	14.327	15.1664	11.7808	11.7005	14.1613	15.0305	11.2148
1962	30	16.5888	6.7854	3.0329	10.0628	7.2782	1.5652	7.9016	5.2442	1.7645	4.6306	2.9962	1.2222	1.1403	2.1265
1962	31	4.9245	6.6623	7.1199	4.0982	8.9553	10.3836	6.9813	7.8706	6.6851	6.085	4.8201	7.8682	4.6838	4.2095

Appendix D : Summary of Input Output Data for 1 Tonne Cocoa Pod Production

Materials List		Plot-1	Plot-2	Plot-3	Plot-4	Plot-5
Input Summary	Unit	Value	Value	Value	Value	Value
1. Crop species						
• Cocoa Seeds	seeds	1265	748	827	520	645
• Cocoa Trees	trees	1100	650	720	450	590
• Coconut seeds	seeds		175	95		
• Coconut trees	trees		104	57		
• Rubber seeds	seeds				495	555
• Rubber trees	trees				200	275
2. Diesel for irrigation (density)	kg	0.74	0.67	0.65	1.01	1.34
3. Polyethylene (Plastic, polybag)	kg	1.29	0.85	1.07	1.38	1.69
4. Fertilizers						
• Urea - (NH2)2CO	kg	30.22	14.80	16.90	29.31	35.36
• TSP	kg	2.96	1.55	2.21	2.48	3.16
• SP-36	kg	13.27	4.66	6.60	15.96	18.71
• Rock Phosphate	kg				0.00	0.00
• KCL (MOP)	kg	16.24	3.89	5.36	12.52	17.47
• Kieserite (MgSO4.H2O)	kg	5.69	2.72	3.16	4.25	6.11
• Organic (manure) fertilizer	m3	1.33	0.90	0.97	1.19	1.42
• Leaf fertilizer	lt	0.24	0.19	0.18	0.21	0.28
• Others						
5. Pesticides						
• Insecticide	kg	0.36	0.31	0.19	0.29	0.35
• Fungicide	kg	1.61	1.59	0.30	1.57	1.12
6. Soil						
• C content	gr	1.65	2.37	2.07	1.62	1.55
• C/N Ratio		8.68	10.3	9.41	9	8.61
• Soil Microbes (Bacteria) : Pseudomonas	cfu	4.60E+08	2.25E+07	3.85E+08	4.65E+05	5.40E+05
• Soil Microbes (fungi): Trichoderma sp	cfu	4.20E+06	1.18E+07	6.10E+05	1.00E+04	2.55E+05
Output Summary						
1. Cocoa Yield						
• Cocoa pod	kg	1000	1000	1000	1000	1000
• Cocoa (dry)	kg	625	476	504	269.21	369.54
• Co-product: Coconut sap	lt		48,800	22,230		
• Co-product: Raw latex	kg				19.50	21.06

2.. Water quality						
• N concentration	mg/ lt	20.00	6.00	9.00	4.00	7.00
• P concentration	mg/ lt	0.39	0.28	0.57	2.50	2.78

Note:
Plot-1 : Monoculture; Plot-2 and -3 : Cocoa-Coconut Agroforestry;
Plot-4 and-5: Cocoa-Rubber Agroforestr

Appendix E: SOM Calculation

SOM Calculation	Plot-1	Plot-2	Plot-3	Plot-4	Plot-5
C (gr)	1.65	2.37	2.07	1.62	1.55
Proportion of C (gr/kg soil)	0.00165	0.00237	0.00207	0.00162	0.00155
Bulk density* (Mg/m3)	1.26	1.22	1.22	1.22	1.22
Soil thickness (cm)	20	20	20	20	20
Conversion factor	1.724	1.724	1.724	1.724	1.724
SOM	4.158	5.7828	5.0508	3.9528	3.782
SOMa**	2.8446	4.08588	3.56868	2.79288	2.6722

Note:
* Data source: Darmawan. (2004). The Effects of Green Revolution Technology during the Period of 1970 - 2003 on Sawah Soil Properties in Java, Indonesia; Department of Soil Science, Andalas University, Padang, West Sumatra, Indonesia

**SOMa is estimated based on the conversion factor.

Appendix F: Representative Data for LER Calculation

Type of Cocoa Cultivation		Yield (s)	Yield in Agroforestry (Yaf)	Yield in Monoculture (Ym)	Partial LER (Yaf/Ym)	Total LER
PLOT-2	Cocoa-Coconut	Cocoa (kg/ha)	476.00	625.00	0.76	1.36
		Coconut (lt/ha)	46,800.00	78,000.00	0.60	
PLOT-3	Cocoa-Coconut	Cocoa (kg/ha)	504.00	625.00	0.81	1.09
		Coconut (lt/ha)	22,230.00	78,000.00	0.29	
PLOT-4	Cocoa-Rubber	Cocoa (kg/ha)	269.21	625.00	0.43	1.11
		Rubber (ton/ha)	19.50	28.80	0.68	
PLOT-5	Cocoa-Rubber	Cocoa (kg/ha)	369.83	625.00	0.59	1.32
		Rubber (kg/ha)	21.06	28.80	0.73	

Appendix G: Laboratory Analysis for Soil Quality

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
"LP PUSLITKOKA"

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LP-592-IDN

FR-LP. 5.10.01.01.01-T

HASIL ANALISIS *(Result of Analysis)* :

Identitas Contoh: Nomor Analisis	Kode Pengirim	Tekstur Cara Pipet: Pasir (%)	Debu (%)	Liat (%)	C Walkley & Black (gram)	N Kjeldahl (gram)	C/N	Ekstrak HCl 25 % *): P_2O_5 (mg)	K_2O (mg)	CaO (mg)	MgO (mg)	Ekstrak NH_4-OAc 1 M pH 7: Na (c mol+)	K *)	Ca	Mg	Nilai Kation	KTK	KB (%)	P_2O_5 *): Ekst. Olsen (mg)	Ekst. Bray I	Ekst. NH_4-OAc pH 4,8 *): S	Fe	Mn Total Destruksi Camp Asam Kuat *)	Ekst. HCl 0,1 N *): Cu	Zn	Al-dd KCl *) 1 N (c mol+)	pH (1:5): H_2O	KCl 1 N*)
01.14.1.0061	M 2	-	-	-	1,65	0,19	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
01.14.1.0062	KR 89	-	-	-	2,07	0,22	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
01.14.1.0063	KR (2000)	-	-	-	1,55	0,18	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
01.14.1.0064	V 13	-	-	-	1,62	0,18	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
01.14.1.0065	K.TLP	-	-	-	2,37	0,23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
01.14.1.0066	J 5	-	-	-	1,60	0,18	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Catatan *(Notes)* :

1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku enam bulan
   (This result is valid within six months)

* Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis,
(Technical Manager),

Sugiyanto ,SP.MP

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Appendix H: Laboratory Analysis for Soil Microbes

UNIVERSITAS GADJAH MADA
FAKULTAS PERTANIAN
JURUSAN MIKROBIOLOGI PERTANIAN
LABORATORIUM MIKROBIOLOGI PERTANIAN

CERTIFICATE OF ANALYSIS OF MICROORGANISMS
No. : A/442/LM/Anls/03/14

Name Sample : Soil From Plantation PTPN XII
Sample Type : Solid
Sample Color : Brown
Sample Sender : Budi Utomo
Sample Date of Entry : February 26, 2014

Tabel 1. The Number of Microorganisms in The Sample

No.	Sample Code	Type of Microorganisms	Quantity (cfu/g)*	Method of Analysis	Media
1.	M-2	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$4{,}60 \times 10^8$ $4{,}20 \times 10^6$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*
2.	J-5	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$3{,}95 \times 10^8$ $1{,}34 \times 10^8$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*
3.	V-13	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$4{,}65 \times 10^5$ $1{,}00 \times 10^4$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*
4.	KR.2000	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$5{,}40 \times 10^5$ $2{,}55 \times 10^5$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*
5.	KR.89	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$3{,}85 \times 10^8$ $6{,}10 \times 10^5$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*
6.	K.TLP	a. *Pseudomonas flourescens* b. *Trichoderma* sp.	$2{,}25 \times 10^7$ $1{,}18 \times 10^7$	*Plating* *Plating*	*King's B Agar Potato Dextrose Agar*

Information : * cfu : *colony forming unit*

Yogyakarta, March 3, 2014
Head of Laboratory,

Ir. Donny Widianto, Ph. D.

Jl. Flora, Bulaksumur, Yogyakarta, 555281
Telp. 0274-523065 Fax. 0274-563062 E-mail:psmikro@faperta.ugm.ac.id

Appendix I: Laboratory Analysis for Water Quality

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
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FR-LP. 5.10.01.01.04-A

LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0001 – A

Nomor analisis *(Number of analysis)*	: 01.14.4.0001
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: M 2
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
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FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0001 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	20	Distilasi, Campuran Devarda
2.	N – NH_4^+	mg/l	1	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	0.39	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.23	Spektrofotometri

Catatan (Notes) :
1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku selama tiga bulan
   (This result is valid within three months)

*) Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sudiyanto, SP., MP)

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
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FR-LP. 5.10.01.01.04-A

LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0002 – A

Nomor analisis *(Number of analysis)*	: 01.14.4.0002
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: KR 89
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

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Hal 1 dari 2

Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
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Accredited KAN Komite Akreditasi Nasional LP-592-IDN

FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0002 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	9	Distilasi, Campuran Devarda
2.	N – NH_4^+	mg/l	2	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	0.57	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.33	Spektrofotometri

Catatan (Notes) :
1. Hasil analisis ini hanya berdasarkan contoh yang diuji *(This result based on the tested sample only)*
2. Hasil analisis ini hanya berlaku selama tiga bulan *(This result is valid within three months)*

*) Tidak termasuk ruang lingkup akreditasi *(Not included in the scope of accreditation)*

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sugiyanto, SP., MP)

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Hal 2 dari 2

Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
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LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0003– A

Nomor analisis *(Number of analysis)*	: 01.14.4.0003
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: KR ((2000)
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

ORIGINAL

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
"LP PUSLITKOKA"
Jl. PB. Sudirman No. 90, Jember - 68118, Indonesia
Telp. +62 331-757132, 487278; Fax. +62 331-757131, 487735,
Email: lappuslitkoka@gmail.com, lappuslitkoka@iccri.net

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LP-592-IDN

FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0003 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	7	Distilasi, Campuran Devarda
2.	N – NH_4^+	mg/l	1	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	2.78	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.22	Spektrofotometri

Catatan (Notes) :

1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku selama tiga bulan
   (This result is valid within three months)

*) Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sudiyanto, SP., MP)

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
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LP-592-IDN

FR-LP. 5.10.01.01.04-A

LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0004 – A

Nomor analisis *(Number of analysis)*	: 01.14.4.0004
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: V 13
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
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FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0004 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	4	Distilasi, Campuran Devarda
2.	N – NH_4^+	mg/l	1	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	2.50	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.11	Spektrofotometri

Catatan (Notes) :

1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku selama tiga bulan
   (This result is valid within three months)

*) Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sugiyanto, SP., MP)

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(*Laboratory for Testing*)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(*Indonesian Coffee And Cocoa Research Institute*)
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FR-LP. 5.10.01.01.04-A

LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0005 – A

Nomor analisis *(Number of analysis)*	: 01.14.4.0005
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: K TLP
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
(Indonesian Coffee And Cocoa Research Institute)
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Email: lappuslitkoka@gmail.com, lappuslitkoka@iccri.net

Accredited KAN Komite Akreditasi Nasional LP-592-IDN

FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0005 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	6	Distilasi, Campuran Devarda
2.	N – NH_4 *	mg/l	1	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	0.28	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.26	Spektrofotometri

Catatan (Notes) :
1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku selama tiga bulan
   (This result is valid within three months)

*) Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sugiyanto, SP., MP)

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
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FR-LP. 5.10.01.01.04-A

LAPORAN HASIL ANALISIS AIR
(Report of Water Analysis)

No. 01.14.4.0006 – A

Nomor analisis *(Number of analysis)*	: 01.14.4.0006
Tanggal terima contoh *(Date of sample received)*	: 06 Februari 2014
Tanggal analisis *(Date of analysis)*	: 07 – 11 Februari 2014
Jenis contoh *(Kind of sample)*	: Air
Uraian contoh *(Sample description)*	: Dikemas dalam botol plastik Aqua kemasan 1,5 liter
Identitas contoh *(Identity of samples)*	: J 5
Nama customer *(Name of customer)*	: Budi Utomo (Dr.Ir. Adi Prawoto , SU)
Alamat customer *(Address of customer)*	: Jember

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Appendix I: Laboratory Analysis for Water Quality (Cont')

LABORATORIUM PENGUJI
(Laboratory for Testing)
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
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FR-LP. 5.10.01.01.04-A

Hasil analisis *(Result of analysis)* : 01.14.4.0006 - A

No. *No*	Macam analisis *Type of Analysis *)*	Satuan *Unit*	Hasil *Result*	Metode Analisis *Method of Analysis*
1.	N – total	mg/l	5	Distilasi, Campuran Devarda
2.	N – NH_4^+	mg/l	1	Distilasi
3.	Fosfor (P_2O_5) total	mg/l	0.35	Destruksi asam kuat, Spektrofotometri
4.	Fosfor (P_2O_5) tersedia	mg/l	0.15	Spektrofotometri

Catatan (Notes) :
1. Hasil analisis ini hanya berdasarkan contoh yang diuji
   (This result based on the tested sample only)
2. Hasil analisis ini hanya berlaku selama tiga bulan
   (This result is valid within three months)

*) Tidak termasuk ruang lingkup akreditasi
(Not included in the scope of accreditation)

Jember, 28 Februari 2014
Manajer Teknis
(Technical Manager)

(Sugiyanto, SP., MP)

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